# DESIGN OF A WATER WORKS SYSTEM AND ELEVATED STEEL TANK

FOR

FRANKLIN, INDIANA

BY

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Armour Institute of Technology

1908

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A THESIS PRESENTED

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TO THE

PRESIDENT AND FACULTY

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# The Design of a complete Water Works System for Franklin, Ind.

The method of procedure in the design of this water works system may be outlined as follows:

First,- the field work, followed by the drawing of a contour map and profiles of all the streets on which pipe lines are to be laid.

Second,- the location of the pumping station, and site for elevated tank.

Third,- the distributing system.

Fourth,- the design of the elevated tank, including a thorough theoretical analysis of the stresses and various members of the tower.

Fifth,- specifications and estimates of quantities.

Under the field work comes the determinations of the elevation of street intersections, the width of the streets, and the length of blocks. A plat of the town was then drawn showing the elevation of street intersections. With the information on hand and the slope between street intersections being constant, a contour map was drawn, followed by a set of profiles on which the pipe line is shown at the required depth below the surface.

The pipe line as shown on the profiles follows the natural contour of the surface at a depth of five feet which in this vicinity is deep enough to protect it against freezing.

Following this comes the design of the pipe system. The supply was figured on the basis of the number of 50 foot lots within the city limits, taking five persons to a lot.

There being 2000 fifty ft.lots, puts the total population at (2000 x 5) = 10,000. The population at present is about 4000, so that this allows for a twenty year increase.

Under the design of the tank comes the design of the tank proper and the design of the tower.

The next step is the writing of specifications. These specify the material with reference to quantity and quality, and workmanship mecessary for the satisfactory completion of the various parts of the system. The last step consiets of an estimate of the quantities required for this system.

---- DESIGN OF DISTRIBUTING SYSTEM AND PIPE LINE.

Allowing 100 gallons per capita consumption for an estimated population of 10,000, gives the total required domestic supply of 1,000,000 gallons every 24 hours.

The number of fire streams that are in use simultaneously are determined by:

Kuichling's Formula

$$Y = 2,8\sqrt{X}$$

Y = number of streams X = population is thousands.

This gives a total of nine fire streams furnishing 250 gallons per minute, or 2250 gallons. Allowing for a maximum play of four hoses, gives the quantity of water required for fire purposes, as 540,000 gallons, for 24 hours.

Therefore the total demand on the system will be 1,000,000 gallons per day.

The next step is to divide the town into districts so as to get the percentage of water required for each section. The boundaries of the districts are as follows:

District (1)

Graham Turnpike to Adams Street, east on Adams Street, to Young Street, north on Young Street to Hamilton Avenue, west on Hamilton Avenue to Graham Turnpike.

District (2)

South on Main Street to Wayne Street, west on Wayne Street to Morton Street, north on Morton Street to Harriott Street, and east on Harriott Street to Main Street.

District (3)

South on Main Street to Wayne Street, east on Wayne Street to Forsyth Street, north on Forsyth Street to Adams Street, west on Adams Street to Main Street.

By assuming five persons to every fifty foot frontage, we find that, district (1) consumes 31%. District (2) consumes 34%. District (3) consumes 35% of the daily consumption, while the maximum number of fire streams must be considered concentrated in one district simultaneously.

To determine the maximum number of gallons required per minute, consider the maximum house consumption as twice the average, or 1,000,000 gallons per day (24 hours) as acting over a space of time of 12 hours.

Assume nine fire streams supplying 250 gallons per minute to act through a space of time of four hours.

Therefore

| | | | |
|---|---|---|---|
| Domestic | = 1,000,000 gallons/ 12 hours | = 1390 | gals. per minute |
| Fire | = 9 x 250 " /min. | = 2250 | " " " |
| | | 3640 | " " " |

Therefore the main leading from the elevated tank will have to be capable of delivering 3640 gallons per minute.

The main leading from the pumping station to the elevated tank will have to deliver the 1,000,000 gallons in twelve hours for domestic consumptionand 540,000 gallons in twelve hours for fire service. Although the latter supply is used in four hours under maximum conditions the time of refilling the tank may extend over a period of twelve hours.

Therefore

| | | |
|---|---|---|
| Fire | 540,000 gal/12 hours | 750 gal.per minute |
| Domestic | 1,000,000 " /12 hours | 1390 " " " |
| | | 2140 " " " |

The next step is to determine the maximum number of gallons which may be needed in any of the three sections. This is shown in the following table:

| | % | Domestic | Fire | Total |
|---|---|---|---|---|
| Section (1) | 31 | 438 | 2250 | 2681 |
| " (2) | 34 | 473 | " | 2723 |
| " (3) | 35 | 486 | " | 2736 |
| | Total | 1390 | | |

SAMPLE COMPUTATION.

By carefully examining the map you will find the maximum conditions will prevail in District (3) when there is a fire in the vicinity of Greenburg State Road and Forsyth Street. This being a residence district, we will assume that one third the total number of fire streams are all that must be concentrated at one point, which amounts to three streams.

By an advantageous placing of the hydrants we can concentrate three streams at any one point without exceeding 200 feet of hose.

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By an advantageous placing of the hydrants we can concentrate three streams at any one point without exceeding 200 feet of hose.

A minimum hydrant pressure of 25 pounds per sq. in. is is required to mantain a 250 gallon stream with 200 feet of hose.

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Assuming the average head on the tank to be 180 feet, and adding to this the difference of elevation between the tank and the point in question which is 20 feet gives a total head of 200 feet. Using 5 feet per second as the maximum velocity we start from the extremity of the line and work back to the tank.

Section 1.

Hougham St. Jefferson St. to Greenburg Rd.

Domestic Supply

132 - 50 ft. lots. Population 132 X 5 = 760

100 gallons per capita 760 X 100 = 76000 gallons per 12 hrs.

= 105 gallons per minute.

Fire Supply.

3 X 250 gallons = 750 gallons per minute.

Total = 750 + 105 = 835 gallons per minute.

Section 2.

Jefferson St. Hougham St. to Hurricane St.

Domestic Supply

160 - 50 ft. lots Population - 160 X 5 800

100 gallons per capita 800 X 100 = 80,000 gallons per 12 hrs.

= 111 gallons per minute.

Fire Supply

3 X 250 = 750 gallons per minute.

Total = 750 + 105 + 111 = 966 gallons per minute.

Section 3.

Hurricane St. Jefferson St. to Adams St.

Domestic Supply

128 50 lots Population 128 X 5 = 640

100 gallons per capita 640 X 100 = 64,000 gallons per 12 hrs.
89 gallons per minute.

Fire Supply
3 X 250 = 750 gallons per minute.
Total = 750 + 105 + 89 = 1055 gallons per minute.

Section 4.

Adams St. Hurricane St. to Main St.

Domestic Supply

224 - 50 lots Population 224 X 5 = 1120

100 gallons per capita 1120 X 100 = 112,000 gallons per 12 hrs.
= 155 gallons per minute.

Fire Supply
3 X 250 = 750 gallons per minute.
Total 750 + 105 + 111 + 89 + 155 = 1210 gallons per minute.

By the use of the diagram for calculating cast iron pipe given in "Turneaure and Russell" the following table was compiled.

| Section | Discharge Gal./ min. | Dia. of pipe in inches | Length in feet | Loss of head / 1000 ft. | Loss of hd./ ft. |
|---|---|---|---|---|---|
| 1 | 855 | 10 | 320 | 4.5 | 5.9 |
| 2 | 966 | 10 | 1200 | 7.5 | 9 |
| 3 | 1055 | 10 | 1000 | 8.0 | 8 |
| 4 | 1210 | 12 | 1760 | 4.5 | 7.9 |
| | | | Total loss of head | | 30.8 |

The available head at the hydrant 200-30=170 feet

$p = .434\ h$

$p = .434 \times 170 = 74$ pounds per square inch.

A glance at the map will show the system employed in the distribution. A large 16 inch main leading from the tank which branches into three 12 inch mains which supply the three main districts. These main trunk lines are all connected so as not to leave any dead ends, and in between these are placed the smaller pipes forming what is known as the " Guderon System."

FRANKLIN WATER WORKS.

General Specifictions and Conditions of Agreement.

The work will be considered and detailed specifications are drawn under the following divisions:

1-Furnishing cast iron pipe and special castings.
2-Furnishing hydrants, valves and valve-boxes.
3-Laying pipe and setting hydrants, valves and valve-boxes.
4-Furnishing and setting up pumping machinery.
5-Furnishing material for, and erecting water tank and tower.

Bidders will divide their bids, giving prices for the work under the separate divisions mentioned above, together with a lump bid for the construction of the complete plant.

It is intended that these specifications, and each contract and specifications shall cover the completion of the work to which it relates.

By the term city is meant the city of Franklin, Indiana, acting through its proper authorities.

Wherever the term "Water Works Committee" is used, it shall be understood to mean the committee representing the the Common Council in the prosecution of the work to be performed under and in accordance with these specifications.

Wherever the term "Engineer" is used, it shall be understood to refer to the Engineer, in the employ of the city, having direct charge of the water works construction, and to his authorized assistants.

Wherever the word "Contracter" is used, it shall be understood to refer to the party or parties contracting to perform the work to be done under these general specificatios, or the legal representative of such party or parties.

Bids will not be received for the work involved under these specifications, except from parties having had experience

in such work, and who can furnish satisfactory froof of their ability to carry to carry on the construction of the whole or part of the system in a thorough and workmanlike manner.

The contractor is to furnish, at his cost and expense, all transportation, plants, tools, labor, materials, and all else requisite to execute and complete the work in the best possible and most expeditious manner, and according to the drawings and specifications and their intended meaning.

He shall employ competent foremen and experienced mechanics and laborers, and shall discharge immediately, whenever requested by the Engineer to do so, any man who is incompotent or disposed to be disorderly, and shall not again employ such such person on the work.

All materials furnished and work done will be inspected by the Engineer, and if not in accordance with these specifications and contract, they will be rejected and immediately removed, and other work done and material furnished in accordance therewith. If the contractor refuses to remove the work the work and materials as above ordered, then the Engineer and water Works Committee shall have the right and authority to stop the contractor and his work at once, and to supply men and materials at the cost and expense of the contractor; such expense to be deducted from any moneys then due, or to become due the contractor from the city.

And it is further intended that inspection shall not relieve the contractor from his responsibility to do true and accurate work; and the contractor shall furnish all necessary facilities, shouldit be deemed advisable to make any examination

of the work already completed. If any be found defective in any respect, he shall defray the expenses of such examinations and of satisfactory reconstruction. If all be found satisfactory such expense, will be paid by the city. The engineer and Water Works Committee shall the right to reject, at any time previous to the final settlement with the contractor any work or materials may be found faulty, even though such faults may have been previously overlooked.

The successful bidder must sign the contract for the work to be done by him, within 10 (ten) days after the contract is awarded to him, and must begin work at the time fixed for him to begin, in accordance with the detailed specifications for the several portions of the work. He shall proceed with the work, prosecuting it with due diligence from day to day, and complete it at the time fixed.

The contractor must follow strictly and without delay, all instructions and orders given by the Engineer in the performance of his work. In the event of the contractor's absence from the work, he must leave it in charge of a duly authorized representative, to whom orders and instructions may be given, If he fails to do this, then the contractor will be held responsible for the proper carrying out of such orders and instructions as it may be necessary for the Engineer to give to any superintendent, foreman or other employe about the work.

The contractor will be held responsible for the entire work until completed and accepted by the city, and until he is formally released from his obligations. He is required

not to assign or sub-let his contract without permission from the city, but must keep it in his name and control until completed and accepted, and in case of his absence from the work, must have a duly qualified person to take care of it.

No charge shall be made by the contractor for any delays or hindrance from any cause during the progress of any portion of the work embraced in his contract.

If the delay be caused by any act or neglect of the city, then he will be entitled to an extension of the time allowed for the completion of the work, sufficient to compensate for the delay, provided the contractor shall give the city immediate notice of the cause in writing. If the contractor fails to oomplete the work at the date specified, he shall forfeit to the city, as confessed the liquidated damages, and amounts named in each of the specifications for the different portions of the work.

Before the work will be considered as completed, all rubbish and unused material due to, or connected with the construction, must be removed and the premises left in a condition satisfactory to the city. All sidewalks and crosswalks must be cleared up streets, curbs, crosswalks, fences and other public and private property disturbed or damaged must be restored to their former condition, and final payment will be withheld until such work is finished.

Should any disagreement or difference arise as to the true meaning of the drawings or specifications at any point, or concerning the character of the work, the decision of the Engineer shall be final and conclusive, and binding on all

parties to the contract.

The city reserves the right to increase or decrease the quantity of work, or any part thereof, to the amount found necessary. No allowance will be made, in case of increase, for any sum above the rate of price bid, nor in case of decrease for any real or supposed damage or loss of profit occasioned by such diminution. The time fixed for the completion of the work will be proportionately increased or diminished.

During unsuitable weather all work must stop when such work would be liable to be injured, and it must be suitably protected from such possible injury.

No extra work will be paid for or allowed, unless the same is done upon the written order of the Engineer. Subject to this condition, extra work will be paid for according to the schedule of prices bid. Where prices for the work are not included in the schedule, ten per cent advance upon the actual cost, as determined by the Engineer, will be paid to the contractor. All claims for extra work must be made in writing before the payment of the next succeeding estimate after the work shall have been performed. Any failure on the part of the contractor to make such claim, will be a forfeit of the same.

All city, county or state laws, ordinances or regulations limiting or controlling the action or operation of those engaged upon the work, or affecting the materials applied to them, must be respected or attended to.

The contractor will be required in his contract to pre-

serve the city from all claims for damages, from any and all causes and nature whatsoever, in connection with his work or any part thereof, and also to act as defendent in each and every suit of any and every nature which may be brought against the city by reason thereof, or connected with the work done under this ~~this~~ contract.

Unless otherwise provided for in the details of specifications, the Engineer during the last week of each month, will make an approximate estimate of the value of the work done during that month, and the contractor will be paid the amount due under his contract, on the fifteenth (15) of the month following.

A final estimate of all work done and materials furnished according to the contract and these specifications, will be made as soon after the Engineer has been notified of the completion of the work, as he can satisfy himself by tests, examinations or otherwise, that the work has been and is finally and fully completed in accordance with the contract and specifications, and the contractor will be paid as hereinafter provided. Before such final payment will be made, the contractor must satisfy the city that all bills for labor and materials used in the work have been paid.

The contractor will be furnished with one set of drawings prints, or tracings, and a set of specifications, giving all the details and dimensions necessary for carrying out his portion the work. Dimensions given in figures will have the preference over the scale where there is any discrepancy.

If the bidder does not fully understand the plans and specifications, or in doubt as to the Engineer's, ideas or

intentions, concerning any part or portion of the work, he must satisfy himself by inquiry of the Engineer, before bidding, for he will be held rigidly to the Engineer's interpretation of the plans after the contract is drawn. The plans and specifications are intended as complete, but should anything be omitted from them which is necessary to complete the work in accordance with the apparent intention of the Engineer, it will be supplied by the contractor, and at no extra cost to the city. Any work done by the contractor which is strictly extra work, will be settled for as above stated.

All materials, lines, grades, must be in full accordance with the plans, and no deviation from the plans and specifications will be allowed, except by written authority of the Engineer and Water Works Committee.

The copy of plans and specifications furnished the contractor must be kept constantly at the work, be well cared for and returned to the Engineer when the work is completed.

The Engineer must stake out all the work and set all necessary grade-stakes; and the contractor is required to preserve all stakes bench-marks etc., set or established along the line of the work, until authorized to remove them. If moved by carelessness or without authority, they will be set if needed, at the expense of the contractor.

The city will furnish the contractor with all the stone for the construction of rubble masonry, and will also furnish broken stone for concrete etc.

Each bid must be accompanied with a certified check or its equivalent, as a guarantee that the bidder will enter into a contract with the city to do the work according to the plans

and specifications, and for the amount of the bid. The amount of such check shall be five-hundred dollars ($500).

This deposit will be retained and placed to the credit of the party whose bid is accepted, and will be forfeited if he fails to enter into and execute the contract awarded to him.

In case the failure of the bidder, to whom the contract is awarded, to sign the contract, the city reserves the right to accept any other bid made, and all checks will be held until contract is signed, when they will be returned.

As security for the proper performance of the work, a bond acceptable to the city of an amount up to one-fourth the amount of the contract, will be required, and the city will pay at the times specified only eighty (80) per cent of the monthly estimates of work properly performed and materials derlivered, after deducting all charges against the contractor retaining the twenty (20) per cent until the completion of the contract and the final acceptance of the work.

Proposals must be enclosed in sealed envelopes, and each must have written on it plainly, the words, "Proposal for Water Works". Each proposal must be addressed to the Secretary of the Water Works Committee of the city of Franklin, Indiana.

No proposal will be received after the limiting time fixed for receiving proposals, and no bidder will be allowed to withdraw his bid after it has been opened and and read, unless the city fails to accept the bids for the work, within fifteen (15) days from the opening of the bids.

All work done must be in strict accordance with the detail

specifications under their appropriate headings, and the general and detail specifications will be attached to and made a part of each contract. The general specifications and conditions of agreement are to be considered a part of the detailed specifications for each part of the work.

The final payment will be made within sixty (60) days after the formal acceptance of the work, by the Engineer and the city. Partial payments made upon the estimates, either monthly or otherwise, shall not be construed as a final or partial acceptance of any portion of the work, or as relieving the contractor in any way, from the responsibility herein contemplated.

The right is reserved to reject any and all bids.

## DETAILED SPECIFICATIONS
## FOR
## FURNISHING CAST IRON PIPE
## AND
## SPECIAL CASTINGS.

The pipe shall be of the kind usually known as "Hub and Spigot", and in general each straight pipe shall be about twelve (12') in length from the bottom of the hub to the end of the spigot. The metal shall be of the best quality for the purpose, made from what is commercially known as "Neutral" Pig-Iron, which shall have been made from iron-ores without the admixture of cinder, and when cast into the pipe the metal shall be tough, and of such density and texture as will permit its being easily cut and drilled by hand.

The city shall have the right to appoint an inspector whose duty it shall be to see that these specifications are strictly complied with; to reject any metal, mold or cast, which would, in his judgment cause imperfection in the work; to supervise the coating, testing and weighing of pipes and castings; to require at any time, specimen rods of the metal for testing, to reject after casting, any pipe or special casting which he may deem below the requisite standard of perfection, and his decision and directions shall be respected and observed by the contractor.

Any palpable defect or imperfection, which may have escaped the notice of the inspector, shall be deemed sufficient cause for rejecting any pipe or casting at any time previous to the final settlement and the completion of the contract.

The pipe-metal must possess a minimum tensile strength of at least eighteen thousand (18000) pounds per square inch.

All the straight pipes shall be cast in dry sand moulds, vertically, with the hub down. Every pipe is to have the initials of the maker's name cast distinctly upon it, and also the year, the class letter, and a number signifying the order of its casting, in point of date; the several different classes of pipe each to have its own series of numbering; the figures and letters to be at least two inches in length, with a proportionate width; the weight of each pipe to be conspicuously painted on the outside, before delivery, with white lead paint at the contractor's expense.

All special castings shall be subjected to the same examinations and tests at the foundry, except the water-pressure

test, as the straight pipe, and shall be marked in a similar manner. The Engineer may reject without proving, any pipe or casting which is not in conformity with these specifications.

Pipes and special castings shall not be taken from the pit and stripped while showing any color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal cooling and contraction by subsequent exposure.

On being removed from the flasks, all pipes and special castings shall be subjected to a careful examination and hammer test for the purpose of detecting imperfections of any kind. They shall then be thoroughly dressed and made clear and free from earth, sand or dust, which adheres to the iron in the moulds; iron wire brushes must be used, as well as softer brushes to remove the loose dust. No acid shall be used in cleaning the castings. After having been properly dressed and cleaned, they shall again be subjected to a thorough inspection and hammer test. The contractor will be required at the foundry, to place all castings in such positions as may be deemed necessary by the Engineer for convenience of inspection.

The pipes and special castings shall be free from scoria sand-holes, air-bubbles and other defects or imperfections; they shall be truly cylindrical in the bore, straight in the axis of the straight pipes, and true to the required curvature or form in the axis of the other pipes; they shall be internally, of the full specified diameters, and shall have their inner and outer surface concentric.

To insure proper diameter of sockets and spigots, a circular iron templet of the required dimensions shall be passed to the bottom of every socket, and a circular ring over every spigot. Care shall also be taken to avoid all excess in diameter of the sockets. No pipes or special castings will be accepted which are defective in joint room, whether in consequence of eccentricity of form or otherwise. No lump or rough places shall be left in the barrels or sockets, and no plugging or filling will be allowed. All pipes and special castings with defective hubs or flanges will be rejected.

After the above described cleaning and inspection, every and special casting shall be heated, in a suitable oven, to a temperature of about 320 F., and while at this temperature, be immersed in a bath of hot coal tar pitch varnish, prePared in general, according to Dr. R. Angus Smith's process. Special care shall be taken to have the surface of all pipe and castings entirely clean and free from rust immediately before putting them in said bath. If any pipe or casting can not be dipped in said bath soon after its removal from the mould, it shall at once be thoroughly coated, with pure linseed oil, in order to prevent the formation of any rust before applying said varnish.

The coating must be durable, smooth, glossy, hard tough, perfectly waterfroof, and not affected by any salts or acids found in the soil, free from bubbles and blisters, strongly adhesive to the iron under all circumstances, and with no tendency to become soft enough to flow when to the sun in summer, or to become so brittle as to scale off in the winter.

After the said coating has become thoroughly set and hard,

every pipe shall be subjected to a proof by water pressure of three hundred (300) pounds per square inch. Each pipe while under the required pressure, shall be sharply rapped with a hand hammer, to ascertain whether any defects have been overlooked; and pipes which may exhibit any defects by leaking, sweating or otherwise, shall be rejected.

All pipes and castings must be delivered in all respects, sound and in conformity with these specifications. Upon their delivery at the point designated, the Wat er Works Committee reserves the right to subject any pipe or casting to to the same water pfoof and hammer tests as are specified to be applied at foundry;, or which may have been broken in transportation, will be rejected when discovered, unless the same may be cut as hereinafter provided. Care must also be taken in handling the pipes and castings during transportation from the foundry to said point or any time after being coated. If, upon its arrival at the designated point of delivery, the spigot end of any of any straight pipe should be found cracked or broken, during transportation from the foundry to the said point or otherwise, such defective portion shall be cut off at the contractor's expense, provided that the same does exceed a length of four (4) feet. A deduction from the proper original weight of such pipe, shall also be made in each case, at the rate specified in the table of weight, for every inch of length so cut off. No pipe or special castings in which the hub is found to be cracked or defective in any respect, will be accepted at said point of delivery or otherwise; nor will any special casting with a defective spigot end be received, or permitted to be cut off, without the written order of the Engineer.

Pipe arriving with the weight or number illegible or omitted, will not be received, but will be subject to the same conditions as cracked or broken pipe, so far as they apply.

All tools, men, materials, required by the Engineer or the inspector in discharging their duties relative to the inspection at the foundry or otherwise, contemplated by these specifications, shall be furnished by the contractor, and at no expense to the City.

SPECIFICATIONS

for

FURNISHING HYDRANTS, VALVES

VALVE-BOXES.

There will required for the system, the following valves, the number being closely approximated only:

Two (2) ten (10) inch gate valves.
Fourteen (14) six (6) inch gate valves.
Two (2) four(4) inch gate valves.

The valves will be of the best quality made and of a design to be approved by the Engineer; they will be of the kind known as double-gate, double-hub, brass mounted. Bidders will state in their proposal what manufacture of gates they propose to furnish.

They must be what are termed "heavy" and must be tested successfully and remain watertight, under a pressure of three hundred (300) pounds per square inch at the factory.

The contractor will be required to guarantee their perfect condition for a period of six months (6) from the final acceptance of the work, and to pay all expenses and damages which may be incurred in keeping them in perfect order for that length

of time.

The valves will be made to open by turning the key to the left. They must be suitablaly coated.

The net area of water-way must not be less than the net area of the pipe of the same nominal diameter, and in all particulars the valves must be of the best form and make, and proportioned for strength, durability and ease of working.

Defective valves will not be accepted, but will be stored, subject to the contractor's order and at his expense and risk.

The right is reserved to vary the number, kinds and sizes to such extent as may be necessary for the interest of the work.

Proposals must state the price per piece for each size, for use in case of increase or diminution in the quantities.

HYDRANTS.

The hydrants must be of the very best quality made, and may be either the Mathews, Ludlow, Waterous, Chapman, Galvin, or other equally good make, acceptable to the Engineer. Bidders will state in their proposals what manufacture of hydrants they wish to furnish. They must be made of the best materials, such as will be durable and will insure perfect ease of motion for every moving part.

Bidders will specify the size of valve or gate opening and inside opening of stand pipe.

Bidders will submit prices for hydrants, with and without frost cases.

The character of the design must be such that all parts are easily accessible, and that repairs may be made at a minimum cost and in a very short time.

The drip must be such as will drain the hydrant perfectly, leaving no water standing in the stand pipe above the connecting pipe; such as will operate positively and certainly; so desgned as to render it impossible to become clogged with anything liable to get into the water mains, or by roots; and such as will not easily get out of order or be difficult to repair.

The hydrants will be of proper length to use where the bottom of the pipe-trench is to be five (5) feet and six (6) inches below the surface grade. They will be designed to open to the left.

The nozzles will be cut with a thread to match the couplings now in use in the fire department of the city. The gate valve must be so designed as to operate easily and freely and not be liable to be clogged or stuck by small pieces of foreign matter, and must be made of or faced with a material which is durable and not easily injured, which will not be liable to stick to its seat, and such that should any slight injury occur to the seat or gate face, the valve will not leak.

Prices will be submitted per piece for the following.

Five (5) hydrants with six (6) inch bottom connections, three (3) two and one-half(2-1/2) inch nozzles. Twenty-seven (27) hydrants with four (4) inch bottom connections, two (2), two and one-half (2 1/2) inch nozzles. Length of stand pipe mentioned above. All bottom connections to be standard bell End.

Defective hydrants will not be accepted, but will be stored at the contractor's risk and expense and held subject to his order.

He will be required to guarantee the perfect working of hydrants for a period of six (6) months from the date of the final settlement, and pay all expenses and damages which may be incurred in keeping them in perfect working order for that length of time.

All hydrants must be tested and stand satisfactorily, a pressure of three hundred 300 pounds per square inch at the factory.

VALVES BOXES.

There will be required, twenty-one (21) cast iron, extension valve-boxes with five (5) inch diameter upright shaft, to be acceptable to the Engineer, for the valves above specified.

Prices must be named per piece for the valve-boxes to fit the valves mentioned in the foregoing list, set in mains laid in trenches varying in depth from four (4) feet six(6) inches to six (6) feet.

All valves after being set, must stand satisfactorily, the test specified for the mains after being laid, viz: a pressure of one-hundred and fifty (150) pounds per square inch, as shown by a correct guage to be attached to a hydrant or hydrants, in the city, at points to be designated by the Engineer, and for such a length of time as the Engineer may desire, in order to satisfy himself of the perfections of the work.

The hydrant will be tested with the hydrant valve or gat e closed., also with the nozzle caps on and the gate or valve open, and each and every defect must be repaired, and at no expense to the city.

The successful bidder must begin the delivery of the hydrants, valve-boxes and valves June 1, 1908.

The proposal for furnishing hydrants, valves and valves-boxes, shall state the time for the full delivery of the materials under this specification. Other things equal, preference will be given to the proposal offering the earliest delivery.

The contractor will be required to forfeit as confessed and liquidated damages, to the city, the sum of fifteen(15) dollars per day for each and every day the final delivery is delayed beyond the time specified in his proposal, and he will be required to reimburse said city for any and all damages and increased cost of work to the city, by reason of such delay, and act as defendent in any and all suits, which may be brought which may be brought against the city by reason of such delay, or from any other cause connected with his or their contract with the city.

The contractor or contractors will be required to contract to preserve and protect the city from all claims of infringe-in the use of patented articles, and to defend any and all infringement suits brought the city, growing out of, or due to the use of their hydrants, valves and valve-boxes.

Drawings or models should accompany each bid.

During the last week of each month, the Engineer will make an estimate of the amount of work done under the speification during that month. On the fifteenth (15) of the succeeding month, the contractor will be paid eighty (80) per cent of the amount due him on this estimate. The balance, twenty (20) per cent will be due and payable within sixty days (60) days of the final completion and test and approval by the

Engineer, and acceptance by the Water Works Committee.

The right is reserved to reject any and all bids.

# SPECIFICATIONS for PIPE LAYING. and SETTING HYDRANTS, VALVES and VALVE BOXES.

The following is an approximate estimate of the total length of each pipe to be laid.

| Size. | Feet. |
|---|---|
| 16 inches. | 1000. |
| 12 inches. | 4600. |
| 10 inches. | 16200. |
| 8 inches. | 14900. |
| 6 inches. | 18200. |
| | 54900 |

The work under these specifications will include the setting of all necessary special castings in the pipe system throughout the city. Also the setting of fire hydrants as specified below.

Also the setting of the following gate-valves with valve boxes.

| | |
|---|---|
| Two (2) | Ten (10) inch gate-valves. |
| Fourteen (14) | Six (6) inch gate-valves. |
| Three (3) | Twelve (12) inch gate-valves. |

The above quantities must be considered only closely approximate, and the right is reserved to modify them as may be found necessary in the progress of the work, without extra compensation to the contractor other than due to the rate of charge for such kind of work.

The contractor will furnish all labor, materials and all plant necessary to lay the pipe in accordance with these specifications, and in a thoroughly first class and workmanlike

BILL OF QUANTITIES.

The following is an approximate estimate of cast-iron pipe and special castings, required for the construction of a water supply system for the city of Franklin, Indiana, in accordance with the annexed plans and specifications.

The sizes given, refer to the internal diameters.

The weight of straight pipe shall be as follows:

| Size | Feet | Weight per foot | Total weight. |
|---|---|---|---|
| 16 in. | 1000 | 128.5 | 128500 |
| 12 in. | 4600 | 84 | 386400 |
| 10 in. | 16200 | 64.6 | 1,046520 |
| 8 in. | 14900 | 47.8 | 712220 |
| 6 in. | 18200 | 33.0 | 600600 |

Any pipe weighing less than the above by more than three (3) percent may be rejected, and no allowances or payments will be made for any excess greater than two (2) percent above these weights. These requirements shall be determined by the weight of each pipe separately. All pipes shall be of such length as to closely approximate twelve (12) feet from face to face of bell when laid in the ground, and the weight per foot shall include the weight of the bell or hub.

The city shall have the right to, and may at any time previous to the shipment of the pipes and special castings, change and revise these specifications as to sizes and amounts, as may be required by the needs of the work, without change in the contract rate of payment.

Contractors in making their bids, will specify the prices per net ton of two thousand (2000) pounds, for which they will deliver each of the different sizes named, as per these specifications. Also the price per pound for special castings made in the ordinary manner, and where necessary, according

to the Engineer's drawings. Detailed drawings of each size of pipe to be used in the work should accompany each bid.

The contractor must begin the delivery of the pipes and special castings on or before and the delivery must continue regularly and uniformly, and in the order of sizes as required.

The special castings must be delivered in ample time for use with the pipe with which they belong, and any extra expense incurred by the city by failure to deliver them in time, must be borne by the contractor.

The proposal for the cast-iron pipe and special castings shall state the time for the complete delivery of the quantities named in this specification. Other things equal, preference will be given to the proposal offering the earliest delivery.

The contractor will be required to forfeit, as confessed and liquidated damages, to the city, the sum of fifteen dollars ($15.00) per day, for each and every day the final delivery is delayed beyond the time specified in his proposal, and he will be required to reimburse said city for any and all damages and increased costs of the work to the city by reason of such delay, and to act as defendant in any and all suits which may be brought against the city by reason of such delay, or from any other cause connected with his or their contract with the city.

During the last week of such month, the Engineer will make an estimate of the amount of the several pipes laid in the trenches during that month. On the fifteenth (15th) of the succeeding month, the contractor will be paid eighty (80)

percent of the amount due him on this estimate. The balance (20 percent) will be due and payable within sixty (60) days of final completion and test and approval by the Engincer, and acceptance by the Water Works Committee.

The right is reserved to reject any and all bids.

LIST OF SPECIAL CASTINGS.

There will be required the following approximate quantities of special castings:

| Crosses | Tees | Plugs | Reducers | Bends |
|---|---|---|---|---|
| 1, 8x10 | 8, 6x6 | 5, 6 in. | 1, 6x8 | 1, 6in, Easy |
| 1, 10x12x16 | 9, 6x10 | 1, 10 in. | | 5, 6 in. Easy |
| 1, 6x6x10x10 | 9, 6x8 | | | |
| 2, 6x10x8x10 | 2, 8x10 | | | |
| 2, 8x12 | | | | |
| 4, 8x10 | | | | |
| 1, 8x6 | | | | |

manner.

Any blow-off air cocks, or other connections necessary to render the work complete will be set by the contractor at points to be designated by the Engineer.

The work will be done along such lines and streets as are indicated on the pipe distribution map of said water works system, and in such other places and streets in said city as may be directed by the city.

The contractor must begin work on or before May 1 1908 and he must prosecute the work diligently and rapidly from day to day and must complete the work within the time specified in his proposal. During each of the months of the time allowed for this work, a proportionate part of the work must be completed. The trenches for the pipes shall be opened under the direction of, and in accordance with the grades and lines to be given by the Engineer, and of such depth that the bottom of the trench shall be five feet and six inches below the grade of the street. Along the same street, the pipe lines will be laid uniformly the same distance from the street center, in straight lines and on straight uniform grades between adjacent hydrants.

Any increase in depth beyond that which is necessary to lay the pipes, in this manner, if ordered by the city, will be paid for per cubic yard of earth excavated and back-filled, provided such extra depth averages three (3) inches for the whole length of extra cut. A corresponding reduction will be made for all lengths of less depth than that specified, and no attention will be paid to any average less than three

(3) inches.

The greatest care must be exercised to insure public safety while the trenches are open, and until all cause of danger appertaining to the work, is removed, by fencing, shoring, watching, lights, etc., and the contractor will be held liable for all damages due to neglect of these precautions.

The pipe will be laid in the order directed by the Engineer; and the storage of pipes and other materials on the streets, and the laying, must be so arranged as to cause the least possible interference with the public, and with the street, side walk and crossings.

In soft ground, each pipe must be laid on three (3) blocks 2in.x2 ft,three for each pipe, laid equal distances apart.

Valves and hydrants, special castings, and all other appurtenances are to be placed at the places, and in the manner designated by the Engineer, specified herein and shown by the plans.

Any omission of branches, stop-cocks or other appurtenances intended to be laid, shall be corrected when required, by reopening the trench, if it has been filled up, and introducing what may have been omitted, and without extra charge upon the part of the contractor.

In hard ground, the bed of the pipe must be even, true and uniform, so that the pipe will bear equally upon it for the whole of its length, and this result must be reached, either by carefully bottoming out the trenches, or by packing in and tamping solidly, sufficient earth to bring it to the

proper grade. Sufficiently large holes shall be dug, to leave the bell of each pipe free, and not resting on the ground at any point.

At the time of laying, the bells and spigots shall be truly adjusted so as to give an uniform lead space all round, and the depth of lead must not be less than two (2) inches, but must be more if necessary, in order to completely fill the rabbet in the hub or bell end of the pipe.

The lead must be of the best quality, pure and soft and must be caulked securely and properly into place.

The gasket must be of clean hemp yarn or oakum, twisted and rammed tightly into place. Before making the joint the bell and spigot must be wiped clean and dry, and the joint run at one pouring. The caulking must be faithfully executed, and the lead driven flush with the face of the work, or until it will set no further.

The pipes are to be swept clean and free from dirt and rubbish before laying, and each time of stopping work the end of the pipe line must be carefully plugged and closed to exclude animals, dirt and water.

All streets and sidewalks, crossings, public or private grounds, shall be restored to their former and original condition, the same as before the work was commenced, and in every way satisfactory to the Engineer.

Great care must be taken not to remove without the consent of the proper parties, any gas pipes, water pipes, sewers, drains or cisterns, or their appurtenances, and they must be carefully shored up, supported and protected, and the pipe

laid in such a way as not to harm them. After passing the above with the pipe, the earth must be very carefully compacted about them. Any damage done to any of the above, or any other public or private property, must be made good by the contractor.

If any boulders be encountered in the trench, they must be taken out and moved off the streets or sunk so that the tops will not be less than one foot below the bottom of the pipe. No stone larger than one man can lift, will be put back in the trench.

Whenever necessary to cross under, or in any manner interfere with a railroad, due notice shall be given to the superintendent of the same, and the crossing must not be made except with his approval as to time and manner.

In back-filling the trenches, the earth must be carefully rammed under and around the pipe up to its center. The rest of the trench may then be filled by depositing the earth in layers not to exceed six inches in thickness and ramming each layer thoroughly. No boulders will be allowed in back-filling, within two feet of the top of the pipe.

In opening the trenches, the surface of the street, if of good gravel or macadam, shall be carefully removed and deposited by itself on one side of the trench, and in back-filling, the surface of the street must be returned to its original condition. Any extra material necessary for this purpose, must be provided by the contractor at his own expense.

All unused or defective material, rubbish, etc., incident to the work must be removed at once, and the street kept clean.

All pieces of pipe not shorter than three (3) feet must be used at once in the line; that which cannot be used must be removed at once to a place designated by the Engineer.

Whenever these requirements, or any portion of them, are unheeded or neglected, the Engineer will give the contractor due notice to that effect, and if the rubbish, etc., is not removed, or the needed repairs made, the Engineer shall have the power to employ men to do such work at the expense of the contractor, and these expenses may be deducted from any moneys due him from the city.

Before being accepted, the pipes will be tested to a pressure of one hundred and fifty (150) pounds per square inch, as shown by a correct gauge attached to any hydrant to be designated by the Engineer. Any breaks, leaks, faults or defects in the pipes, or the work, must be made good and repaired by the contractor, at his own expense. Such tests shall be continued until the Engineer is satisfied that there is no leak or defective part in the whole system. The expense of this test (except the pay of those in the employ of the city) will be borne by the contractor.

The contractor must leave the work in perfect order, and it must stand any pressure, up to one hundred and fifty (150) pounds per square inch, to which the Engineer may wish to test it, and must conform in every other particular to the specifications, both general and detail, so far as they apply.

The contractor shall maintain the pipe system in perfect order for a period of six months from the time of its final acceptance by the city, and shall repair at his own expense

all breaks, leaks and faults which in the work, by reason of faulty material or faulty workmanship, and shall pay all damages resulting therefrom. During this time, he shall maintain the surface of the streets, in their original undisturbed condition.

Pipe laid, will be measured from center to center of special castings on cross-lines, or from center of special casting to end of line, and from center to center of hydrants.

Where specials are inserted and plugged, measurements will be made to the end of the the line.

HYDRANTS.

All hydrants will be carefully examined by the Contractor, to see that they are in perfect working order and free from rubbish, dirt, stones, etc., before setting them, and when defects exist, he must call the Engineer's attention to the Fact.

The trench to receive the hydrants will, in clay, open, porous, sandy or gravelly soil, be excavated of sufficient size, and at least one-quarter of a yard of course gravel or broken stone shall be laid beneath and around the hydrants, up to a point one foot from the drip: Then the earth shall be tamped securely to the surface. In sandy or gravelly ground, enough broken stone shall be placed about the drip, to keep it free from clogging.

The foot of the hydrant shall be securely braced behind, to prevent injury to the bottom joint, and care must be taken to set the hydrants truly vertical. Each hydrant shall be set

truly at grade and will stand upon a flat stone or piece of plank, 2in. x 12in. x 12in.

Setting Valves.

The contractor will examine all valves carefully, and all found defective must be rejected. Care will be taken to see that all the dome and packing-gland nuts are set up tight and properly.

All valves will be set uniformly with reference to property or curb lines, as directed by the Engineer, and no variations greater than one-foot from the uniform location, will be permitted.

Proposals will be submitted in the following forms for the work as specified above:

| | | | | | | |
|---|---|---|---|---|---|---|
| Price | per | lineal | foot, | for | laying | four(12) inch pipe. |
| " | " | " | " | " | " | Six(6) inch pipe. |
| " | " | " | " | " | " | eight(8) inch pipe. |
| " | " | " | " | " | " | ten(10) inch pipe. |

The prices must include the setting of all hydrants, valves, valves-boxes, etc.

The proposals for laying cast iron pipe, special castings, etc., shall state the time for the full completion of the work, as per this specification. Other things being equal, preference will be given to the proposal offering the earliest completion of the work.

The contractor will be required to forfeit, as confessed and liquidated damages, to the city, the sum of fifteen dollars ($15) per day, for each and every day the final delivery and erection is delayed beyond the time specified in his proposal, and he will be required to reimburse said city for any and all

damages and costs of the work to the city by reason of such delay, and to act as defendent in any and all suits which may be brought against the city by reason of such delay, or from any other cause connected with his or their contract, with the city.

During the last week of each month, the Engineer will make an estimate of the materials furnished and the work completed under this specification during that month. Eighty (80) per cent of this amount due the contractor will be paid the contractor upon the 15th. of the month following. The balance (20) per cent will be paid within sixty (60) days of the completion of the work after test and approval by the Wter Works Committee.

The right is reserved to reject any and all bids.

DESIGN OF AN ELEVATED TANK.

The first step in the design of an elevated tank is to determine upon its capacity.

The second step is to determine the location in order to get the most economic distribution.

The third step is to determine upon the height of the tank in order to give a proper head.

---

After due consideration we decided that the most economic way of maintaining our water works system would be running the pumps for twelve hours and shutting down over night. This method requires larger pumps, but the extra cost is more than compensated for, in the decrease of fuel used, and the decrease in cost of maintainance by nearly fifty per cent.

Taking the daily consumption at 1,000,000 gallons and the fire supply 540,000 gallons per 4 hours we will get at the capacity of the tank in the following manner. Assuming that one-fourth of the total daily consumption is used at night and adding to this the amount needed for fire service will give us the capacity of the tank.

$$\begin{array}{rrl} 1/4 \times 1{,}000{,}000 = & 250{,}000 & \text{gallons} \\ & \underline{540{,}000} & \text{"} \\ \text{Capacity of tank} = & 790{,}000 & \text{"} \end{array}$$

Inorder to be on the safe side we made the capacity of the tank 800,000 gallons.

The success of this system will depend upon having the tank full when the pumps shut down. This can be accomplished by the use of 2,000,000 gallon pumps which are capable of delivering 1,000,000 gallons in the twelve hours.

After giving consideration to the elevation and centralization we decided to place the tank at the intersection of Graham Turnpike and Greenwood Turnpike.

---

The height of the tank was calculated by assuming a fire at a point which is a maximum distance from the tank, and adding to this the domestic supply all along the line. From this we calculated the loss of head. The required pressure at hydrants is 75 pounds per square inch which is equivalent to a head of 172.8 feet; adding to this the loss of head already found we have the required head at the tank with respect to the point considered.

The point at which the tank was located is of somewhat higher elevation than the surrounding country. To fulfill the required condition we had to support the tank on a tower 140 feet high.

The design of the tank proper is a simple matter. Beginning at the top the thickness of metal required for each five feet of head may be determined by the use of the formula,

$$t = \frac{2.6\ hd}{8000}$$

$h =$ the distance in feet below the top. $d =$ diameter of pipe in ft. The thickness of the plates used in the bottom of the hemi-spherical bottom are one-half the thickness of those used in the lower course of the tank.

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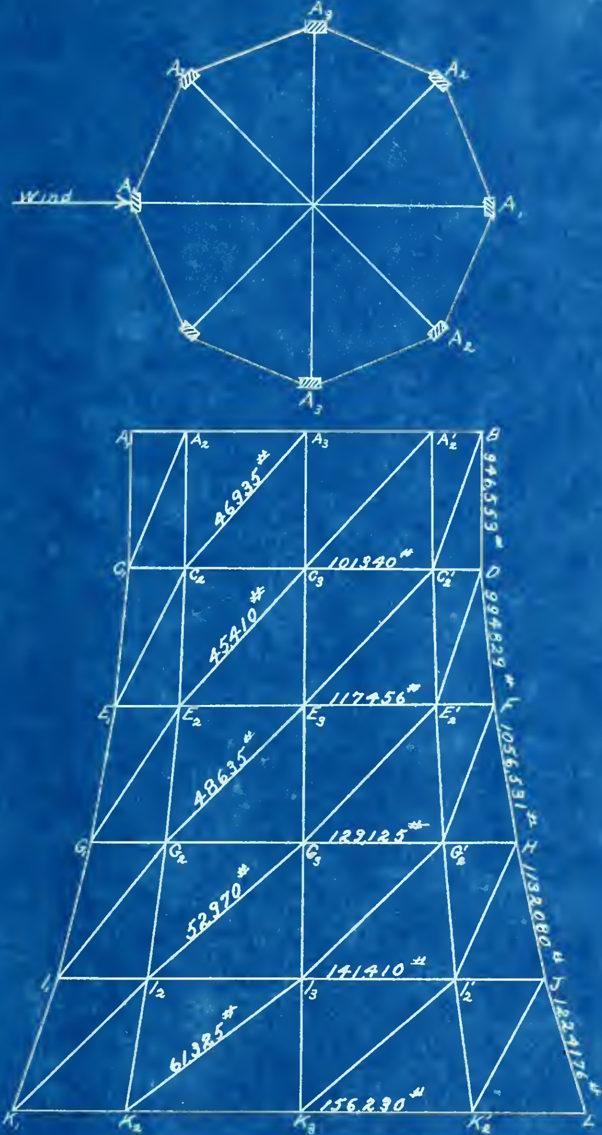
The next step is the design of the tower. This turned out to be a very difficult and complicated piece of work. After spending a considerable amount of time in reference work we



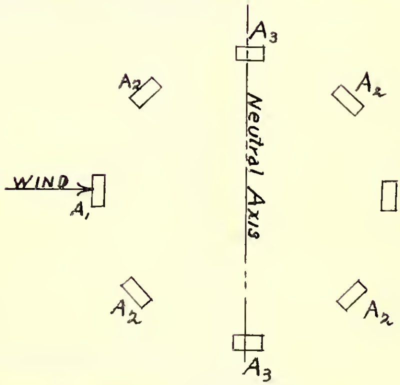

STRAIN SHEET

came to the conclusion that authors did not wish to commit themselves upon such a work, as the designing of the struts and diagonals contain very complicated stresses. They, however, all agree upon the same method for analizing the stresses in legs. To complicate matters all the more the legs in our design change their direction at each panel point.

The dead load stress in each leg will be one eight the weight of the tank when full, and as the legs diverge the stress will be increased by the secant of the angle which the leg makes with the vertical.

The method for determining the wind stresses in the legs is as follows:

Pass a horizontal section through the legs at any point and the section cut will be as shown in diagram. Consider the w wind acting in a direction as shown by arrow. Pass a line through the center of the legs $A_3$—$A_3$ and call this the neutral axis.




Let $A =$ the area of one post.

Let $p =$ the unit stress.

Then, as the stress varies directly as the distance out from the neutral axis,

$p_2$ = the unit stress in $A_2 = .7p$

$M$ = total moment about neutral axis.

$M = 2A_1pr + 4(p/r \times .7r)A_2 \times .7r - (Apr + 4 \times .49rp)A$

$Apr(2 \times 1.999) \quad 2Apr$

$\frac{M}{4} = Apr \quad \frac{M}{2} = 2Apr$

$M = 2A\,pr + 4A_2.5pr = 2A_1pr + 2A_2pr$

$\frac{M}{2} = 2A\,pr$ $\quad \frac{M}{4} = A\,pr$ $\quad A,p$ = stress in ~~part~~ post $A = \frac{M}{4r}$

$\frac{M}{2} = 2A_2 pr\ 4\ A_2 X .7r\ X\ .7p$

$\frac{M}{8} = A\ X.p\ X.7r = .5A\,pr$ or $\frac{M}{8X.7r}$

$A_2p$ = stress in post $A_2 = \frac{M}{5.6r}$

Sample calculation:
Calculation of the stress in section H-J of leg and final design of that memmber.

Take moments about a line passed through I-J

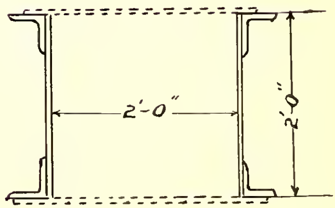
| | | |
|---|---|---|
| Moment of tank | 85700 X 139.2 | = 11,929,440 |
| Moment of legs | 2X4X28X8X50X56 | = 5,017,600 |
| | | 16,947,040 |

$P = \frac{16,947,040}{80} = 216,570$ pounds wind stress.

Dead load.

| | |
|---|---|
| Weight of sections (1+2+3)Sec. 12° | = 12570 |
| 1/8 weight of tank full 883500Sec. 12° | = 902940 |
| Total dead weight | 915510 |

Maximum stress in member 915510 216570 1,132,080
Use 4-- 9/16" plates(Two riveted together.




4 Ls 8" X 8" X 7/8"

Area of plates = 54.67
" " angles = 52.92

Total area = 107.59 sq in.

$I = bh^3/12 = 13824/12\ X18/16 = 1296\ X\ 2 = 2592$
I of angles = 5276.92
Total moment of inertia 7868.92

$r = \sqrt{7868.92/107.59} = 8.6$

$P = 12500 - 13440/8.6 = 10936.8$

Area = 1,136,080/10936.8 = 107.2

Required area = 107.2 Actual area = 107.59

SAMPLE CALCULATION.

Calculation of maximum diagonal stress in section G,H,I,J

Take moments about the plane passes through I-J and dividing this by 4r gives the stress acting at the panel point $I_1$

M = 16,947,040 ft. lbs.
Stress at I 16,947,040 /25.95 X 4 = 163,266 pounds.

Stress in $G, E_1$ 129,018
163 — 129018 = 34248 pounds.
Vertical component of stress in $I, G_2$ = 34248/2 = 17124 lbs.
" " " " " $G_2 I_2$ 92157 — 17124 = 75033
Stress at I = 16,947,040/25.95 X 5.6 = 116,619 pounds.
Vertical component of stress in $I_2 G_3$ 116619 — 75033 = 41586 Lbs.
" " " " " $G_3 I_3$ = 51586 lbs.
" " " " " $I_3 G'_2$ = 41586 lbs.
" " " " " $G'_2 I'_2$ 41586 — 92157 = 133743 lbs.
" " " " " $I'_2 H$ 133743 116619 17124 lbs.
" " " " " J H 163266 lbs.

Maximum diagonal stress = 41586 X Sec. 50° 17′ = 60050

A = 60050/18000 = 3.33 sq.in.

Round steel bar 2 1/16" in diameter.

Sample Calculation.

Calculation of the maximum strut stress along section I-J

The horizontal component of the diagonal stress that goes into $I_1$ — $I_2$ = -16,600 lbs.

The horizontal component of the leg stress that goes into $I_1$ — $I_2$ = 63,000 lbs.

The horizontal component of the diagonal stress from the panel below that which goes $I_1$ — $I_2$ = 0

Resultant component in strut = -79600 lbs.

The horizontal component of the diagonal stress that goes into $I_3$ - $I_2$ = -32810 lbs.

The horizontal component of the stress that goes into $I_2$ — $I_3$ = -80640 lbs.

The horizontal component of the stress (diagonal stress) from the panel below that goes into $I_2 - I_3 = 11632$

Resultant compression in strut: $32810 + 71820 - 11632$ $= -113450$

The horizontal component of the diagonal stress that goes into $I_3 - I_2' = -32810$

The horizontal component of the diagonal stress of the leg that goes into $I_3 - I_2' = -96050$ lbs.

The horizontal component of the stress (diagonal) from the panel point below that goes into $I_3 - I_2' = 28686$

Resultant component stress in strut; $32810 + 96050 - 28686 = -128860$ lbs.

The horizontal component of the diagonal stress that goes into $I_2' - J = -16600$

The horizontal component of the leg stress that goes into $I_2' - J = -124810$ lbs.

The horizontal component of the diagonal stress from the panel point below that goes into $I_2' - J = 28686$

Resultant component in strut: $16600 = 124810 - 28686$ 141,410 lbs.

Maximum stress 141410 lbs.

Use 4 angles 4" X 4" X 7/16" laced together.

Ares 4 angles $= 13.24$

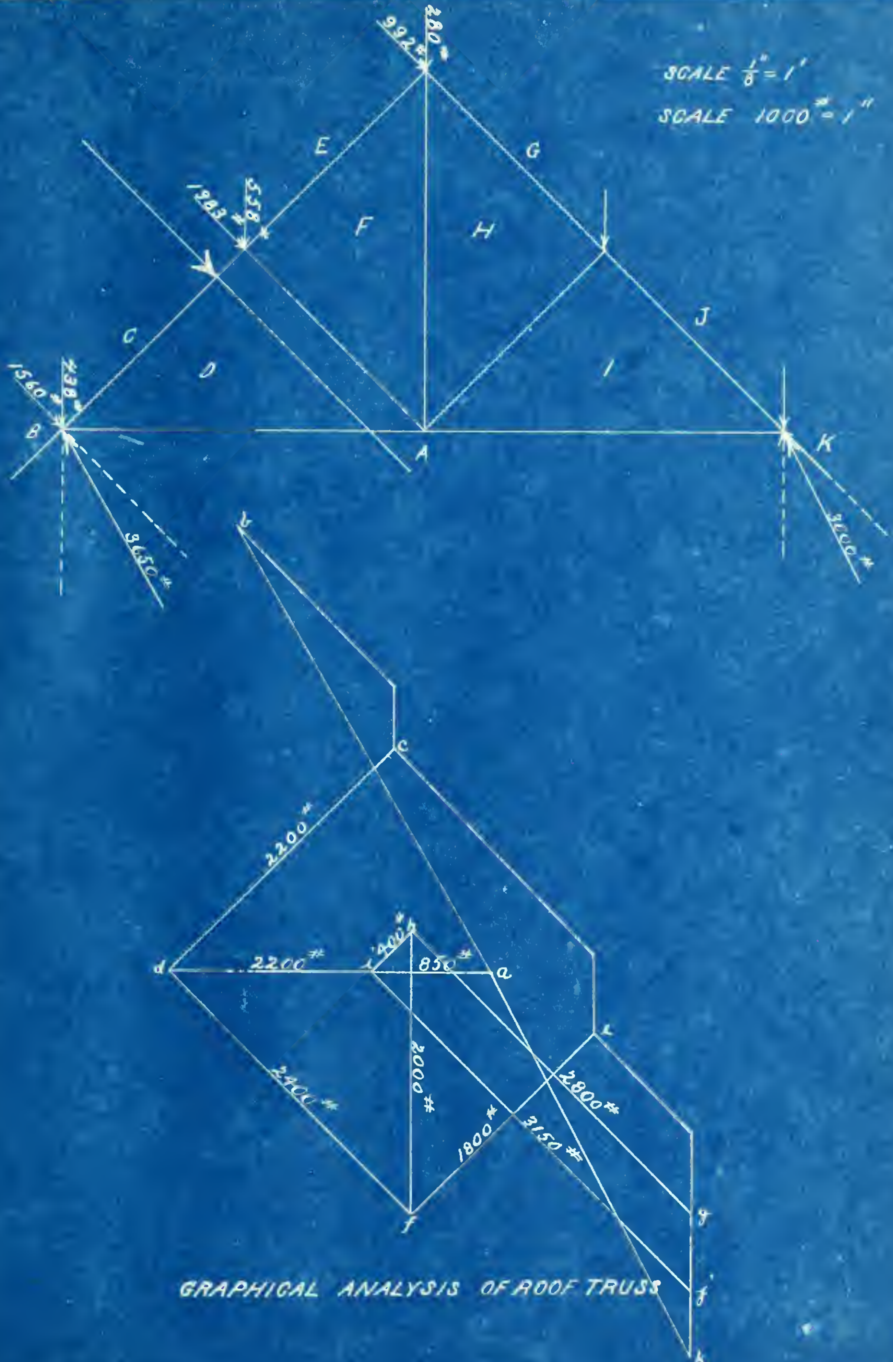
I of angle $= 4.97$

$I = I' + Ad^2$ $\qquad I = 4.97 + 3.31 \times \overline{7.84}^2 = 208.42$

$4I = 208.42 \times 4 = 333.68$ $\qquad r = \sqrt{833.68/13.24} = 7.93$

$P = 12500 - 7344/7.93 = 11574$

$A = 141410/11574 = 12.8$ sq. in. $\qquad$ Actual area $= 13.2$ sq. in.




GRAPHICAL ANALYSIS OF ROOF TRUSS

## DESIGN OF ROOF TRUSS.

The roof system consists of eight trusses or sixteen half trusses.

Roof slopes at an angle of 45°

The round load at an angle of 45° = 36.1"/sq.ft.

The distance between trusses is = 7.85 ft at bottom.

The dead load on each truss 10.2"/sq.ft.

The covering consists of three rows of circular plates overlapping.

The portion of load taken by each truss is that which acts upon a section of the developed cone.

Span 40'    Rise 20'

TABLE OF STRESSES

| Members | Stresses | Lengths |
|---|---|---|
| C--D | -2200 | 14.14' |
| E--F | -1800 | 14.14' |
| G--H | -2800 | 14.14' |
| I--J | -3150 | 14.14' |
| I--A | + 850 | 20.00' |
| A--D | +2200 | 22.00' |
| D--F | -400 | 14.14' |
| F--H | +2000 | 20.00' |
| H--I | - 400 | 14.14' |

The smallest size angle that will stand a 7/8' rivet is 3x3"x3/8". Using the maximum stress here given the size found will fall within this limit.

Therefore 3x3"x3/8" angles are used through.

The center rod is of steel 1,1/16 in diameter.

DESIGN OF FOUNDATION.

| | |
|---|---|
| Weight of tank | 186000 |
| Weight of roof | 17000 |
| Weight of bottom | 82500 |
| Total | 255500# |

Weight taken by each leg $\frac{255500}{8} = 31937$

Weight of each leg = 20550

Total dead load on foundation from each leg

= 31937 x 20550 = 52490#

Maximum tension in tower section of each leg due to wind = + 288280.

Resultant tension = 288280 - 52490 = +235,790#

This must be taken by the anchor bolts.

Each leg is anchored with four anchor bolts

$\frac{235790}{4} = 58,947$ = stress taken by each bolt

$\frac{58947}{18000} = 3.27$ sq.in. of steel = 2,1/16" rod.

Use 4 -- 2,1/16" rods.

Concrete weight 150"/ cu.ft.

$\frac{235790}{150} = 1752$ cu.ft. = volume of concrete needed to hold leg in ground.

Maximum compression ~~comparison~~ due to dead and wind load = 1,224,176 in tower section of leg.

The soft bearing load for loam is about 2 tons per sq.ft.

$\frac{1,224176}{4000} = 307$ sq.ft.

Use a hexagonal concrete ring of trapizoidal cross section. Width of lower base 11' and upper base 5ft. and 7'high.

This will give a foundation of sufficient weight to be stable and with sufficient bearing area.

The anchor rods pass through the concrete and are bolted in a plate 4'x4"x7/8" at bottom.

A shoe is placed on top the concrete into which the anchor bolts are fastened.

SPECIFICATION

for

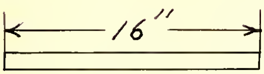
WATER WORKS, TANK and TOWER for

FRANKLIN, IND.

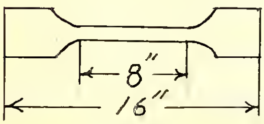
TANK SPECIFICATIONS (general)

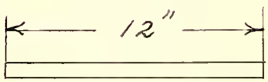
The metal composing the tank shall be soft, open-hearth steel, containing not more than 0.06 per cent phosphorus, and having an ultimate strength of not less than 54,000, nor more than 62,00 pounds per square inch, an elastic limit of not less than which shall be silky in character. Before or after being heated to a cherry red and quenched in water at 80 F. the steel shall admit of bending while cold, flat upon itself, without sign of rupture on the outside of the bent portion.

All test samples shall be cut from finished material.




TENSILE TEST
PIECE
AREA = $\frac{1}{2}$ sq. in.




BENDING TEST
PIECE
WIDTH = 4 x THICKNESS

Tensile test pieces to be at least 16 inches long, and to have for a length of eight (8) inches an uniform planed-edge, sectional area of at least one-half (1/2) square inch, the width in no case to be less than the thickness of the piece. Bending test pieces are to be twelve (12) inches long, and to have a width of not less than four times the thickness, with edges filed smooth. If required by the Engineer, the contractor will provide four (4) certified samples of each thickness of plate used in work, these samples to be (2) two inches wide and sixteen (16) inches long.

For the purpose of identification the number of the melt or heat of steel shall be stamped on each plate produced there from. At least one full set of tests, both chemical and physical, as above specified, shall be made of each melt, and such additional tests may be made as, in the judgement of the inspector, seem essential for corroborative purposes under varying conditionsor methods of treatment of the metal, All plates must be free from laminations and surface defects, and shall be rolled truly to the specified thicknesses. Complete facilities for the tests and inspections shall be provided by the contractor, as required. Material may be inspected at the mill by such party as may be approved by the Water Works Committee of the city of Franklin, Indiana.

The plates and angles shall be shaped to the proper curvature by cold rolling. No heating and hammering shall be allowed for straightening or curving, and no scarfing shall be done at a temperature below that of ignition of a hard-wood hammer handle, and no work shall be done upon the steel be-

tween such temperature and that of boiling water.

The work shall be carefully and accurately laid out in the shop, and the rivet holes punched with a center punch, sharp and in perfect order, from the surface to be in contact. The diameter of the punch shall not exceed that of the rivet by more than one sixteenth (1/16) inch, and the diameter of the die shall in no case exceed that of the punch by more than one sixteenth (1/16) inch. Rivet holes in plates having a thickness of three-fourths (3/4) inch and over, shall either be drilled, or if punched, shall be reamed not less than one-eighth (1/8) inch larger than the die sides of the holes and sharp edges shall be trimmed.

All calking edges shall be planed to a proper bevel. All parts must be adjusted to a perfect fit, and properly marked before leaving the shop.

In assembling the work, the rivet holes shall match so that hot rivets may be inserted without the use of a hammer. The use of the drift pin will not be permitted. Eccentric holes, if any, must be reamed, and if required, larger-sized rivets shall be used in such holes.

The best grade of soft charcoal iron rivets to be had in the market, shall be used. Sufficient stock must be provided in the rivets, to completely fill the holes and make a full head. The rivets shall be driven at such a heat as will admit of their being finished in good form with a button set, before the rivet has cooled to a critical point. As often as may be deemed advisable for the purpose of testing the work rivets shall be cut out at the direction of the inspector.

The quality of the rivet metal and of the workmanship shall be such that the fracture of the rivet so removed at random shall show a good tough, fibrous structure, without any crystalline appearance, and there shall be no evidence of brittleness. Loose rivets must be promptly replaced, no rivet calking being permitted.

All seams must be calked thoroughly tight with a round-nosed calking tool, by workmen of acceptable skill. Great care must be taken not to injure the under plate.

All workmanship must be first class in every particular. Defective material and workmanship may be rejected at any stage of the work, and must be properly replaced by the contractor as directed.

Estimating the courses from the top of the tank downwards, the upper course shall be of one-quarter (1/4) inch steel: the second course shall be of one-quarter (1/4) inch steel; the third course shall be of one-quarter (1/4) inch steel; the fourth course shall be of five-sixteenths (5/16) inch steel; the fifth course shall be of three-eighths (3/8) inch steel; the sixth course shall be of seven-sixteenths (7/16) inch steel; the seventh course shall be of one-half (1/2) inch steel; the eighth course shall be of nine-sixteenths (9/16) inch steel; the ninth course shall be of five-eighths (5/8) inch steel; the tenth course shall be of eleven-sixteenths (11/16) inch steel; the eleventh course shall be of three-fourths (3/4) inch steel; the last course shall be of thirteen-sixteenths (13/16) inch steel.

The size and spacing of the rivets for each course

is given as follows:

The upper course; vertical joint 5/8 " rivets 2 5/8"c. c. 2 1/8 " between pitch lines, 1 1/8 " to edge of plates; horizontal joint 5/8 " rivets 2" c. C. 1" to edge of plate.

Second course; vertical joint 5/8" rivets 2 5/8" c. c. 2 1/8" between pitch lines, 1 1/8" to edge of plate; horizontal joint 5/8" rivet 2" c. c., 1" to edge of plates.

Third course; vertical joint, 5/8" rivets 2 5/8 c. c. 2 1/8" between pitch lines, 1 1/8" to edge of plate, horizontal joint 5/8" rivets 2" c. c., 1" to edge of plate.

Fourth course; vertical joint, 5/8" riverts, 2 5/8" c. c. 2 1/8" between lines, 1 1/8" to edge of plates; horizontal joint, 5/8" rivets, 2" c. c. 1" to edge of plate.

Fifth course; vertical joint 3/4" rivets 2 5/8" c. c. 2 1/8" between pitch lines, 1 1/4 to edge of plates, horizontal joint 3/4" rivets 2 1/4 c. c. 1 1/4 to edge of plates.

Sixth course; vertical joint 3/4" rivets 2 3/4" c. c. 2 1/4" between pitch lines, 1 3/8" to edge of plate; horizontal joint 7/8" rivets 2 5/8" c. c. 1 1/2" to edge of plate.

Seventh course; vertical joint 7/8" rivets, 2 7/8" c. c. 2 3/8" between pitch lines, 1 5/8 to edge of plate; horizontal joint 1" rivets, 3" c. c., 1 3/4" to edge of plate.

Eight course; vertical joint 7/8" rivets, 2 7/8" c. c. 2 3/8 between pitch lines, 1 5/8" to edge of plates, horizontal joint 1" rivets 3" c. c. 1 3/4" to edge of plate.

Ninth course; vertical joint, 7/8" rivets 2 7/8" c. c., 2 3/8" between pitch lines, 1 5/8" to edge of plate; horizontal joint; 1" rivets 3" c. c., 1 3/4" to edge of plate.

Tenth course; vertical joint, 1" rivets 2 7/8" c. c., 2 3/8" between pitch lines, 1 3/4" to edge of plate; horizontal joint 1" rivets 3" c. c., 1 3/4" to edge of plate.

Eleventh course; vertical joint 1" rivets 3"c. c. 2 1/2" between pitch lines 1 7/8" to edge of plate; horizontal joint 1" rivets 3" c. c. 1 3/4" to edge of plate.

Twelfth course; vertical joint 1" rivets 3" c. c. 2 1/2" between pitch lines, 1 7/8" to edge of plate; horizontal joint, 1" rivets 3" c. c., 1 3/4" to edge of plate.

After completion the tank shall be tested by filling with water, and the leaks, if any shall be promptly and thoroughly calked. The tank must be thoroughly watertight before acceptance.

All inspections shall be made under the direction of the Engineer, or his authorized assistant, and he shall have general supervision of the work.

## TANK.

### Detailed Specifications.

There will be required one steel tank, forty (40) feet in internal diameter and sixty (60) feet high; constructed in accordance with this and the general specifications and plans on file in the office of the Water Works Committee, marked "Elevation and Details of Tank".

The tank shall consist of twelve rings or courses, and shall measure exclusive of seam or lap joint five (5) feet to each course; and each course shall not contain more than six (6) plates.

The thickness of plates will be determined by a micrometer caliper; all plates "under gauge" will be rejected.

The lap for double riveted joints shall be six (6) diameters of rivet in width. the laps for single riveted joints shall be three (3) diameters of the rivet in width.

The vertical seams of all courses shall be double riveted. All roundabout seams shall be single riveted.

All seams in the circular course shall be lapped and the rivets driven hot and finished with a hand set. The vertical seams in each course of the tank, to break joint equi-distant from the vertical seams in the course next below. All rivets under angle irons shall have counter-sunk machine heads, finished flush and with the conical hand driven heads.

The edges of all plates shall all be carefully trimmed to a short bevel, and be calked with a short blunt tool; and all joints shall be made water-tight, under natural head or pressure of water in the tank, and without putty, lead or gaskets of any kind.

At the top of the tank and flush with its upper edge, there shall be riveted an angle iron ring, 8" X 8" X 7/8" insection. This ring will be riveted to the tank by means of three-fourths inch rivets, spaced 2 1/2" c. c.

A balcony shall be provided around the tank, attached to tank by means of brackets. All details of balcony, brackets, railing etc., shall conform to the "Plans of Tank".

There shall be provided two ladders, on the outside of tank from the balcony to trap door in roof, and the other reaching from the roof to the bottom of the tank, on the inside. All details of ladders including attachment to tank, shall

conform to the details as shown on the plans.

The tank will be covered with a roof composed of a single thickness of boards cut segmentally and supported as shown on the plans.

The roof to be covered with 1/4" steel plates in three courses, each course lapping as shown on the plans. A trap door shall be provided in roof, permitting access to the interior of the tank.

All details shall conform to the "Plans and Specifications"

There will be required as shown in the drawings above referred to a circular hole sixteen(16) inches in diameter, to receive the sixteen (16) inch cast iron influent pipe as per detail.

In the erection of the tank, the upper and lower rivet holes in the vertical ~~vertical~~ seams, shall be first "stiched" with bolts, and such holes as do not come fair, shall be reamed until the rivet will pass through, and the head seat square on the plate, and where the reaming will inlarge the holes more than one-sixteenth (1/16) inch, the hole shall be reamed to take the next commercial size of rivet.

In erecting the tank the rings or courses shall be be kept concentric to a "plumb" line, suspended from the inside staging truly over the center of the tank bottom, and any rings which under this condition come out of "plumb" or which may not be concentric to the ring next below, or to the "plumb" line, shall be rejected.

The joints in the angle iron rings, shall be made with covers or fish plates, lapping the end of angle irons, fourteen and one-half (14 1/2) inches. The fish plate of th lower

interior angle-iron ring (one each joint) shall be of four and one-half(4 1/2) by five eights iron. The angle-iron rings shall be made up with not more than (4) joints each.

The hemi-spherical bottom shall be constructed of steel plates 5" X 5" X 7/16", which shall be bent to the curvature while cold.

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## General

Proposals will be accompanied by a plan , dimensions, sizes of members, thickness of materials, etc.

All metal in the structure, except rods, which require welding or forging, will be steel. All steel comprising the principal parts of main posts must be made by the Open Hearth Process. All other steel may be made by either the Open Hearth or Bessemer Process.

All tests and inspection of material shall be made at the place of manufacture prior to shipment.

Specimens for determining the tensile strength, limit of elasticity and ductility, shall be determined from a standard test piece cut from the finished material.

Rivet steel shall show an ultimate strength of from 48,000 to 58,000 pounds per square inch. Elastic limit, not less than 1/2 the ultimate strength. Elongation (1,400,000/ ultimate) strength.

Bending test, 180 degrees flat upon itself without fracture on the outside of bent portion.

Structural steel, the same as above, except ultimate strength, 55,000 to 65,000 pounds.

In steel made by the acid process, the phosphorus limit shall be 0.08 per cent; made by the basic process, 0.04 per cent.

Wrought iron used in making rods shall be first class refined iron, known as best bridge iron. The surface must be free from blisters, cinder spots or other injurious defects. Must be made welded together, without seams or ragged or torn edges.

Broken fragment shall show a good fibre, clear and clean, free from cinder spots and other foreign material.

LOADING.

The structure shall be proportioned for the following loads:

1. The weight of the structure.
2. The weight of the water in the tank.
3. A wind pressure of 50 pounds per square foot over 1/2 of diametrical plane of tank, and a uniform load of400 pounds per each vertical foot of tower. The wind forces will be assumed acting in any direction, and members must be proportioned for that direction which will give a maximum stress.

UNIT STRESSES for PROPORTIONING MEMBERS.

Compression.

Members in compression shall be designed by the following formula.

$P = 12,500 - 40\ l/r$
$P =$ Allowed stress per square inch.
$l =$ Length between support in inches.
$r =$ Least radius of gyration in inches.

No mainpost to exceed 125 radii of gyration in length.

No other strut to exceed 150 radii of gyration or such length that the fibre stress due to the bending from its own

weight exceeds 4,000 pounds per square inch.

TENSION.

| | | |
|---|---|---|
| 10,000 | pounds per square inch net section in | Plates. |
| 18,000 | " " " " " " " | Bracing. |

SHEAR.

7,220 pounds per square inch.

Bearing.

| | | |
|---|---|---|
| 15,000 | pounds per square inch on | rivets. |
| 20,000 | " " " " " | pins. |
| 400 | " " " " " | stone caps. |
| 600 | " " " " " | concrete. |

For wind stresses the above unit stresses may be increased by 25 per cent.

## DETAILS of CONSTRUCTION.

Anchor bolts shall always be provided. In cases where the wind force ( the tank being empty) produces unstable equilibrium, they must be of such strength as to prevent over-turning.

Compression members shall be of the open type, no closed section being used.

Bearing plates for distributing pressure over the foundations must be attached in such a way as to evenly distribute the load throughout the entire area.

All joints to be made in main post above, and as near practical to a horizontal strut. Splices are to be made with plates on all sides of the columns with sufficient rivets or bolts to throughly hold the parts together. Batten plates at end of compression members shall not have a less length than the distance between rivet lines connecting them to channels.

The pitch of rivets in them shall not exceed four diameters of the rivet used.

The distance between connections of lattice or lacing bars to the flange of a channel shall not exceed two times the depth of the member, nor shall they be inclined to the axis of the same less than 45 degrees. The thickness of the lacing bars shall not be less than 1/60 of this distance. Lattice bars shall be riveted at their intersections. The width of the lattice and lacing bars shall not be less than 2 1/2 times the diameter of the rivet used.

The size of the rivet for various members: 7/8" throughout.

In angles and other shapes the diameter of the rivet will generally not be less than 1/4 of the leg of the angle used in the flanges. However, no greater rivet than 1" will be used.

In work that does not have to calked the pitch of rivets shall never exceed 6 inches or 16 times the thickness of the thinnest outside plate, nor be less than 3 diameters of the rivet.

In work that requires calking the maximum pitch shall never exceed 10 times the thickness of the thinnest plate used, and shall not be less than three diameters of the rivet.

The distance between the edge of any piece and the center of rivet hole must never be less than 1 3/4 times the diameter of the rivet, except for bars less than 3 1/2 times the diameter of the rivet in width.

A curved girder must connect the main posts to each other where the posts connect to the tank. This girder shall be connected to the tank by means of rivets pitched not greater than four diameters, and shall be of sufficient strength to stand

the thrust and bending moments induced by the horizontal component of the stress in the posts, and shall be rigidly connected to the posts. Its outer flange shall be stiff enough to prevent sagging, or must be supported at intervals by means of braces to the tank.

All rods shall be provided with some adjustment for length. Where they are threaded the ends shall be upset to make up for the decreased area, or else the rod shall be of enough greater size throughout its entire length to allow for this deduction.

At proper intervals horizontal rods from the main posts shall run out and connect to the inlet pipe to hold the same securely inposition.

The inlet pipe must be so provided as to allow for changes of height of tower.

## WORKMANSHIP.

All workmanship shall be of first-class. All abutting surfaces of compression members must be planed or turned to even the bearings so that they shall be in such contact throughout as may be obtained by such means. At the joint between the bearing plate and pieces directly above, the plate need not be planed. It, however, must be carefully straightened.

The diameter of the punch shall not exceed by more than 1/16 of an inch the diameter of the rivet used. All holes must be clean cut, without torn or ragged edges.

Rivet holes must be accurately spaced. The use of drift pins will only be allowed for bringing the several parts together, and they must not be driven with such force as to disturb the metal about the holes.

The rivets must completely fill the holes, having full heads concentric with the rivet., of a height not less than 6/10 the diameter of the rivet, and shall be in full contact with the surface or be countersunk when so required, and machine driven wherever practicable.

Built members must,when finished, be true and free from twists, kinks, and open joints between component pieces. The diameter of the hole shall be not greater than that of the pin by more than 1/32 of an inch.

All pins must be smooth and truly circular. Pilot nuts must be provided where necessary, to preserve the threads while pins are being driven. Fillers must be used wherever necessary to fill vacant spaces on pins or bolts.

Detail pieces, if necessary may be bent hot without annealing. If a steel piece im which the full strength is required has been partially heated, the whole must be subsequently annealed.

LADDER.

A latticed post may serve as a ladder from the ground to a point 6 feet below the balcony. From this point a ladder will extend to the balcony and from there to the top of the tank, being firmly secured thereto. When latticed posts are not used, ladder will extend to about 8 feet above ground.

PAINTING.

All work shall be covered before leaving the shop with one coat of graphite paint thoroughly mixed with pure boiled linseed oil, and a small amount of Japan dryer, except the contiguous surfaces of the plates forming the tank. This

portion shall not be painted. All other parts inaccessible after assembling must be well painted before assembling.

After the work has been erected, the whole shall be painted with one coat of same, and all parts not accessible for painting after erection shall be painted before.

INLET PIPE

The inlet pipe will generally be built of standard cast iron pipe, AND WILL BE FURNISHED TO THE BUILDERS OF THE TOWER, UNLESS OTHERWISE ARRANGED. The builders of the tower, however, to erect this pipe and connect same to tank.

ERECTION.

The builder of the water tower will erect the work, will put in place the inlet pipe, will build the roof and complete the work in all particulars, unless otherwise specified.

He will assume the responsibility such as is usually incurred by builders of such work, and at all times have a competent man in charge.

Rubbish and other unsightly material, caused by his operations, will be removed or disposed of upon completion of the work.

In cases where the foundations are to be built by parties other than the builders of the water tower, the latter will furnish anchor bolts, and sketch for setting the same, to the former, who will set these bolts in the foundations as they are built, locating them exactly as shown on the sketch.

FOUNDATIONS

The foundations shall be concrete, built according to foundation plans furnished by the builder of the tower.

Excavation shall be carried well below the frost line, to a firm footing--deeper than shown on plans if necessary, to secure this result, but at an increased cost, to be agreed upon.

Wooden forms to bring the foundations to the shape indicated on the drawings shall be built for receiving the concrete, which shall be mixed and placed as follows:

Concrete shall be made of one part Portland cement, three parts sand and five parts broken stone and gravel. The mixing of this concrete to be done by hand on platforms. The cement and sand shall first be thoroughly mixed dry by turning over and over until it is of uniform color. After this is done, the stone or gravel, thoroughly moistened, shall be added. The whole will then be thoroughly mixed by turning over with shovels, sufficient water being added to make the whole mass a tenacious and quaking mixture. The concrete so mixed shall be immediately deposited in the foundations in layers not exceeding six inches thick, each layer to be thoroughly and compactly tamped until the whole mass is perfectly solid, and free mortar appears on the surface. No concrete shall be put in the foundations which from any cause has been allowed to set or partially set.

NOTE:--Concrete caps shall be mixed one part Portland cement, two parts sand, three parts broken stone, and shall be smoothly finished.

The anchor bolts shall be firmly held in place so that they will not be moved while depositing the concrete.

In the concrete specified as above the cement used shall be one of the best brands of Portland. Its weight per cubic

foot shall not be less than one hundred pounds. After an exposure of one day in air and six days in water it shall develop a tensile strength of not less than four hundred pounds per square inch. It shall be in prime condition.

The sand shall be course, sharp and clean, free from clay or loam.

The broken stone or gravel shall not be larger than two inches in any direction, and shall be entirely free from dirt and other foreign substances.

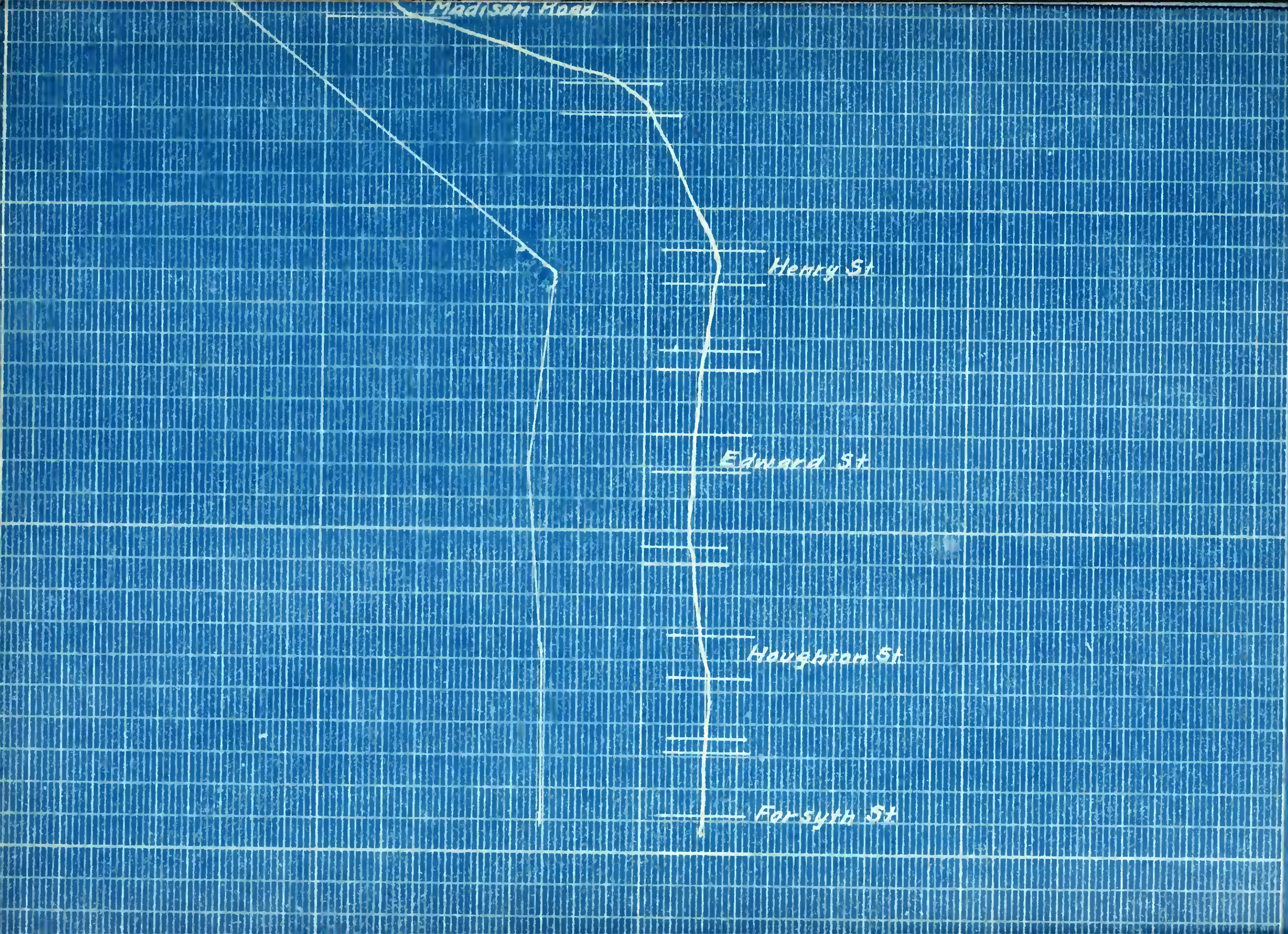
If the location of the work is such that considerable economy can be obtained by the use of either rubble masonry or hard burned brick instead of concrete, as specified above, special arrangements and specifications will be made for the use of such material.

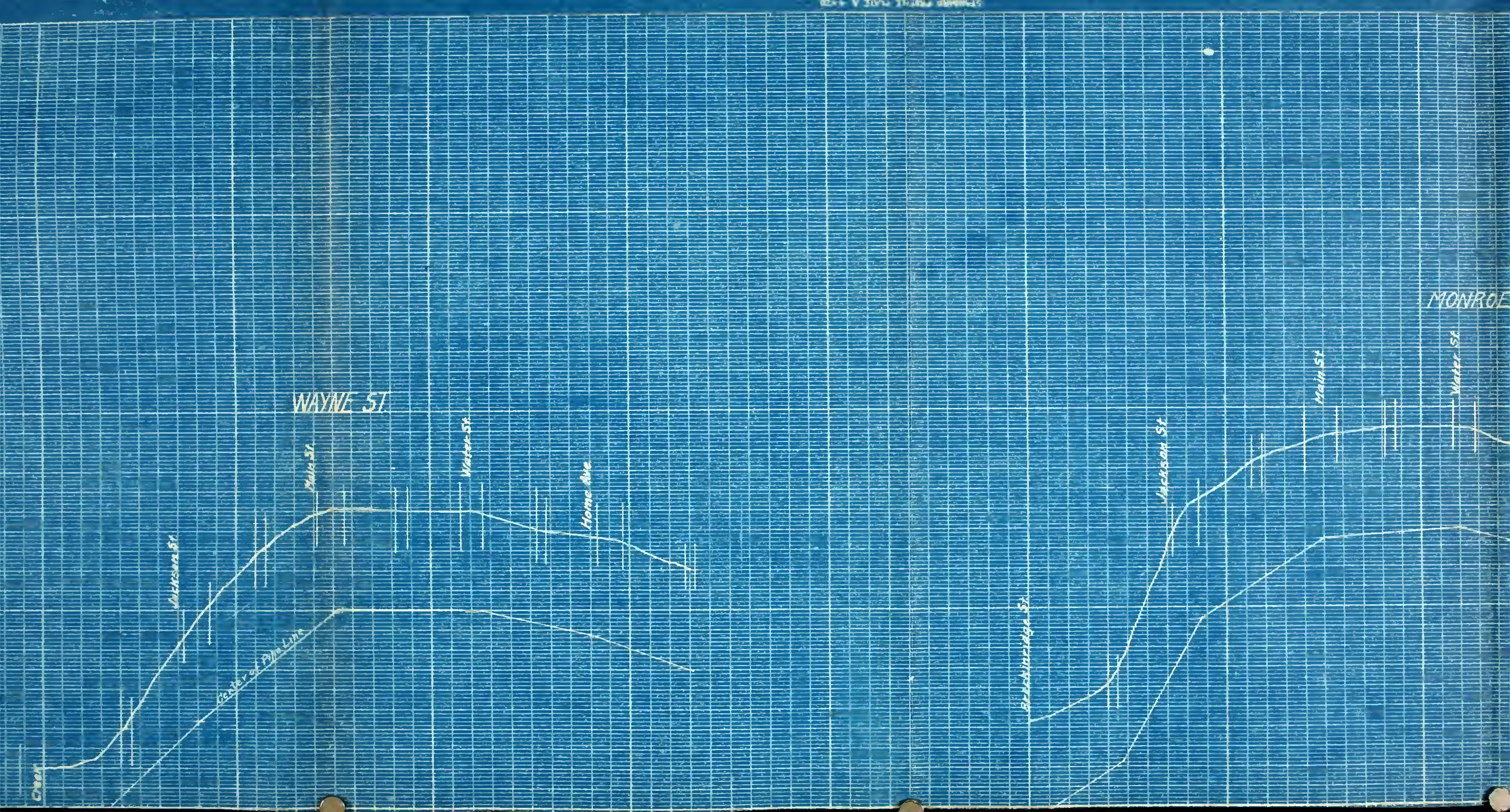

GREENWOOD TURNPIKE
P C C & St L R.R.
GRAHAM TURNPIKE
JOHNSON AVE.
TERRE HAUTE ST.
CINCINNATI ST.
PRATT ST.
HOWE
SAMUEL
YANDES ST.
KENTUCKY ST.
DUANE ST.
RICH ST.
CENTRAL AVE.
HERRIOTT ST.
BANTA ST.
ADAMS ST
KING ST.
WALNUT ST.
MORTON ST.
29' Contour
27' Contour
25' Contour
23' Contour
18' Contour

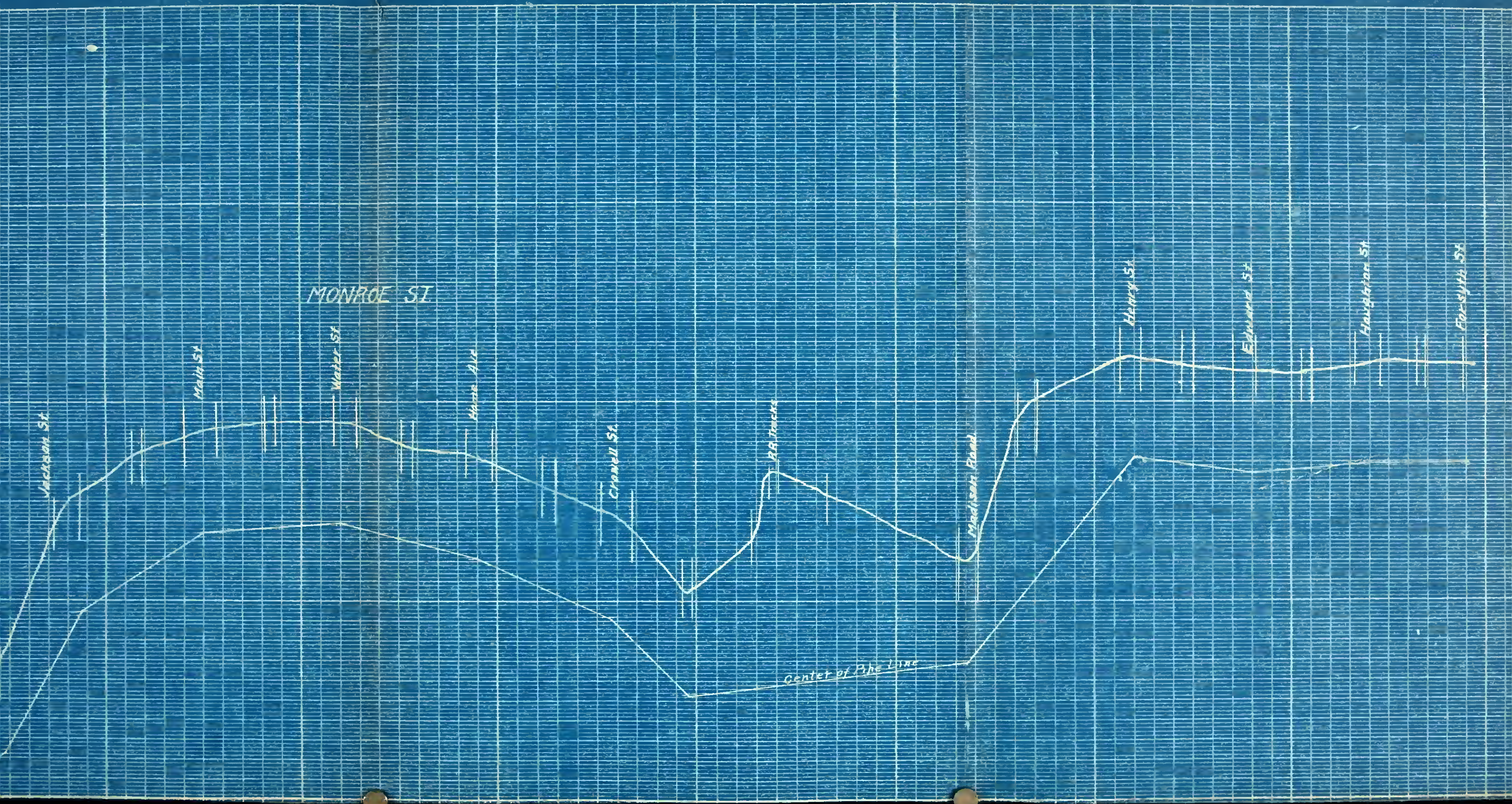

GREENWOOD TURNPIKE
GRAHAM TURNPIKE
P.C.C. & St.L. R.R.
JOHNSON AVE.
TERRE HAUTE ST.
CINCINNATI ST.
HAMILTON AVE.
BENNETT ST
VAWTER ST.
PRATT ST.
HOWE ST.
SAMUEL ST.
OYLER ST.
OHIO ST.
YANDES ST.
HURRICANE ST.
YOUNG ST.
KENTUCKY ST.
DUANE ST.
FICH ST.
WALNUT ST.
BANTA ST.
ADAMS ST.
25' Contour
23' Contour
18' Contour
19' Contour
18' Contour
17' Contour
16' Contour
13' Contour
12' Contour
8' Contour
7' Contour
10' Contour
12' Contour
19' Contour
21' Contour
23' Contour

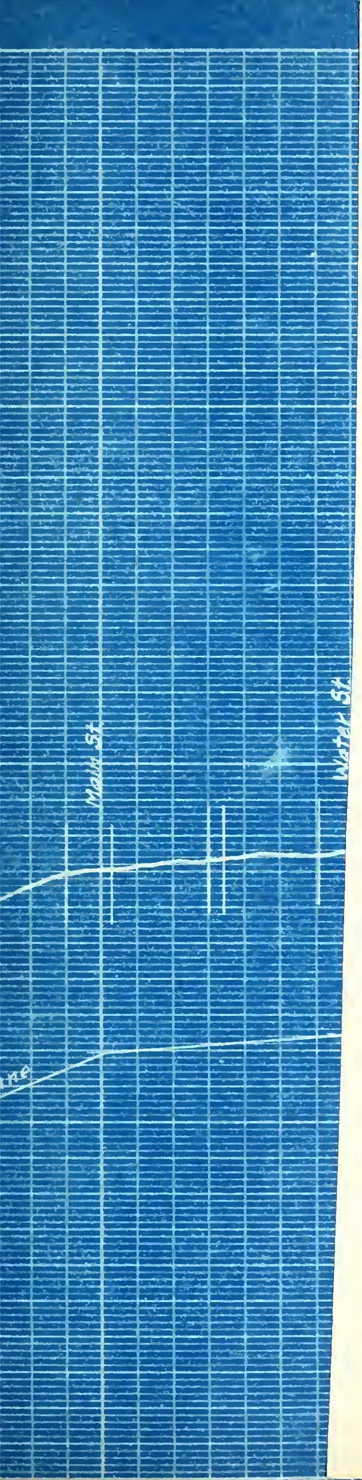
FLAT OF
FRANKLIN
CONTOUR MAP
JUNE 2, 1904.
SCALE 1" = 200'.
KING ST.
VAUGHT ST.
WEST ST.
BRECKINRIDGE
MADISON ST.
UTTZ ST.
JEFFERSON ST.
JACKSON ST.
MAIN ST.
WATER ST.
HOME AVE.
CROWELL ST.
MONROE ST.
WAYNE ST.
4' Contour
2' Contour
YOUNG'S CREEK.
M.P.&F. Div. of C.C.C.&St.L. R.R.
GREEN LAWN CEMETERY.
SOUTH ST.
MAUXFERRY GRAVEL ROAD.
PIT ST.
CENTER ST.
DUNN ST.
JULIA ST.
RIDGE ST.

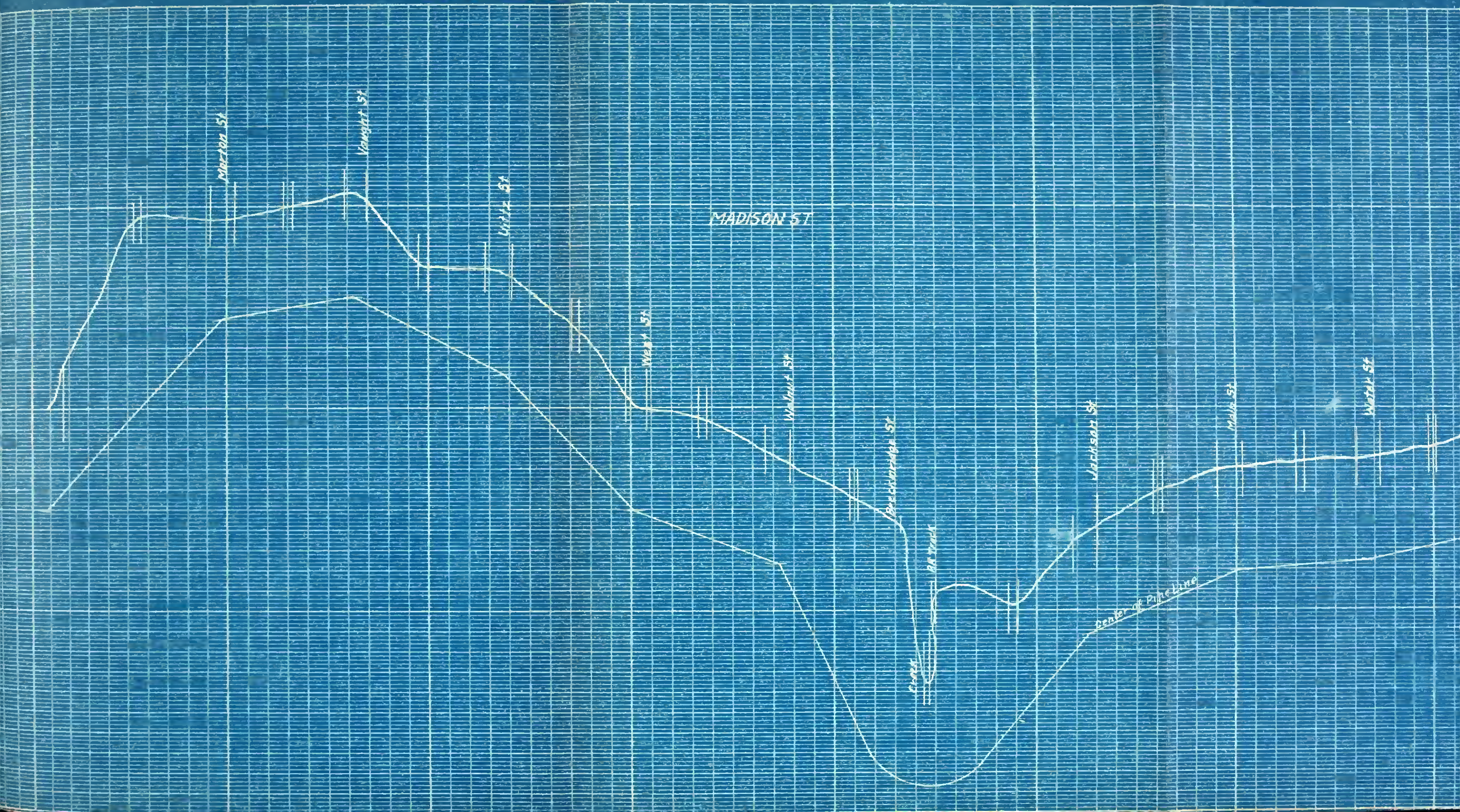
ST.
BRECKINRIDG
JACKSON ST.
MAIN ST.
WATER ST.
HOME AVE.
CROWELL ST.
HENRY ST.
EDWARD ST.
HOUGHAM ST.
FORSYTH ST.
19' Contour
21' Contour
23' Contour
4' Contour
2' Contour
MONROE ST.
WAYNE ST.
DAME ST.
PARK ST.
GREENBURG STATE ROAD.
CROSS ST.
CEMETERY.
SOUTH ST.
CENTER ST.
PIT ST.
DUNN ST.
JULIA ST.
RIDGE ST.
MADISON ROAD.

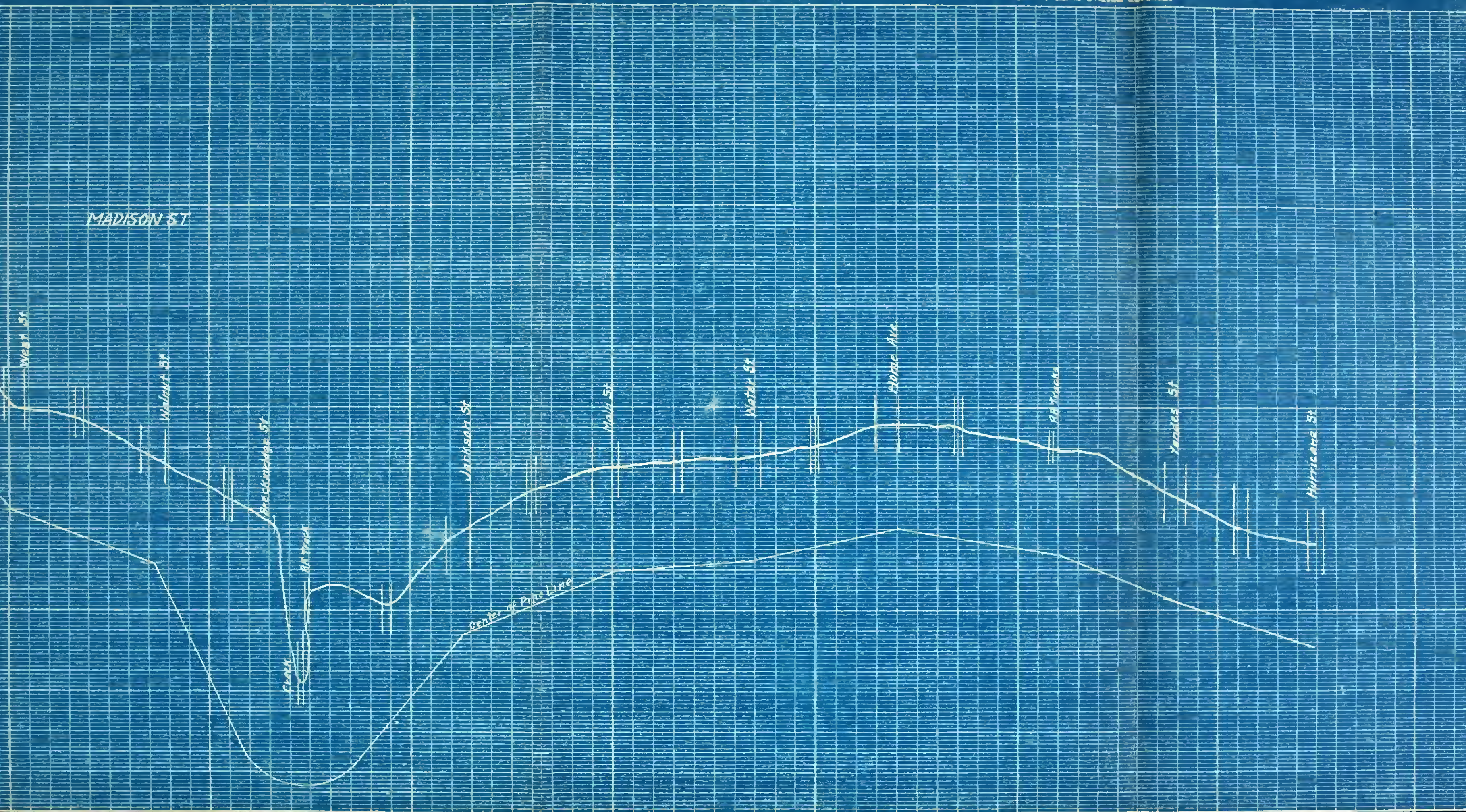

Madison Road
Henry St
Edward St
Houghton St
Forsyth St

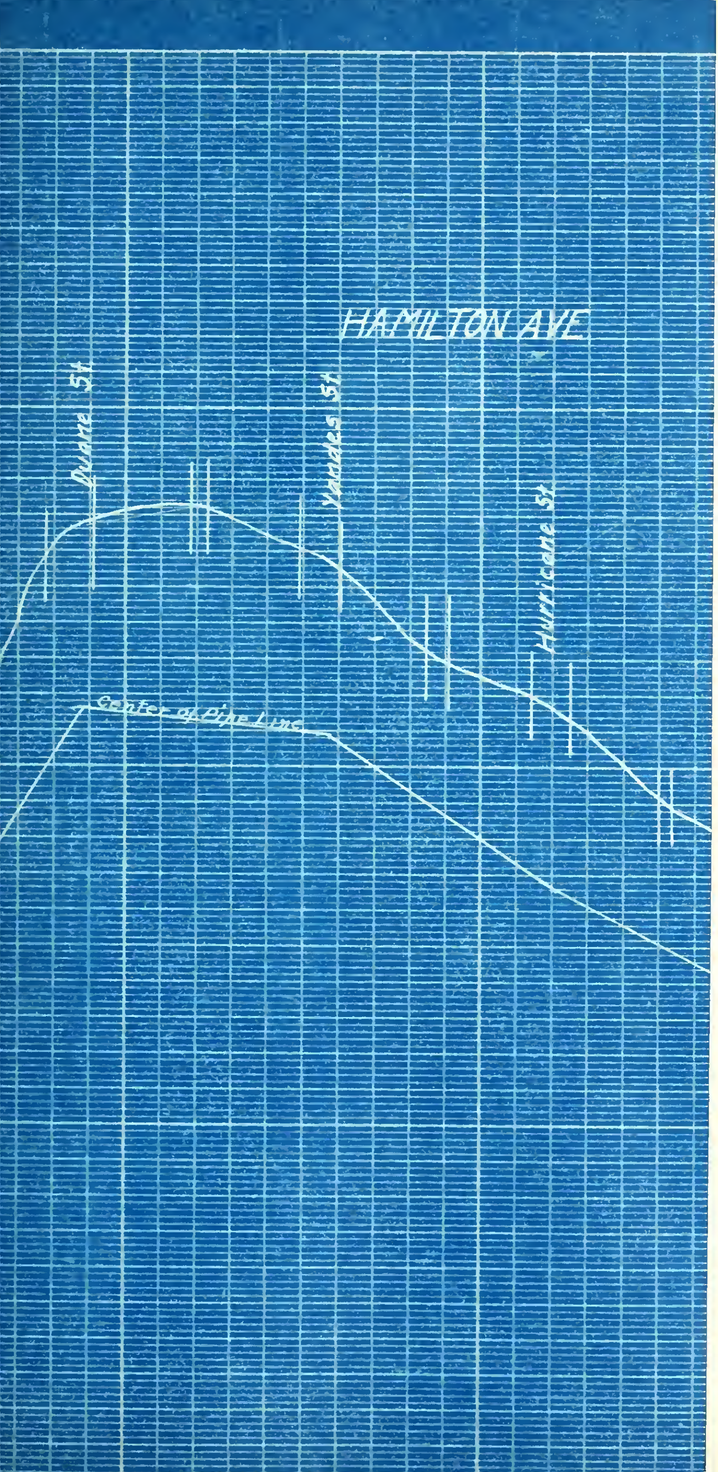

WAYNE ST.
Creek
Jackson St
Main St.
Water St
Home Ave
Center of Pipe Line
MONROE
Breckinridge St.
Jackson St
Main St
Water St

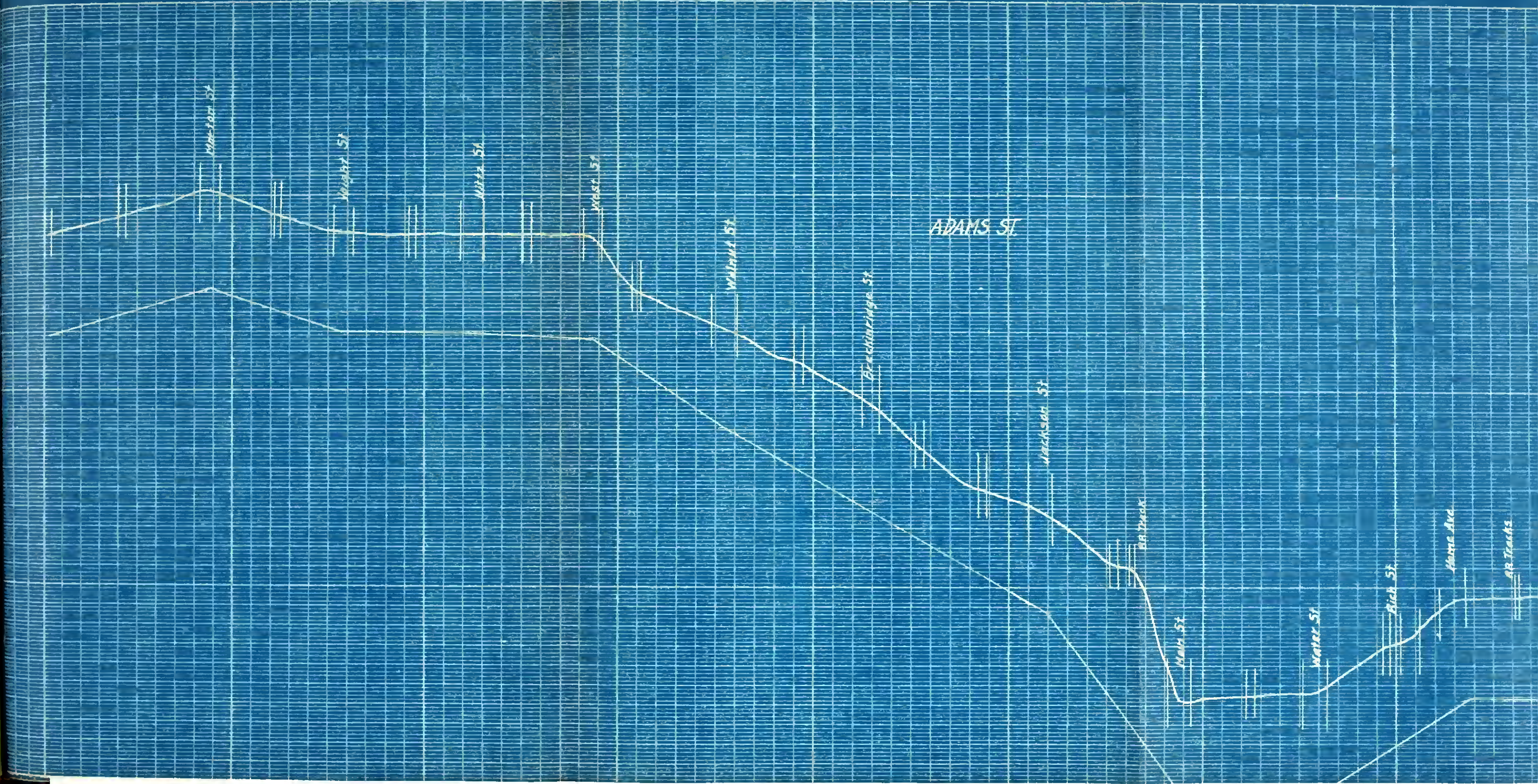

MONROE ST.
Jackson St
Main St
Water St
Home Ave
Crowell St.
R.R. Tracks
Madison Road
Henry St
Edward St
Houghton St
Forsyth St
Center of Pipe Line


Main St
Water St

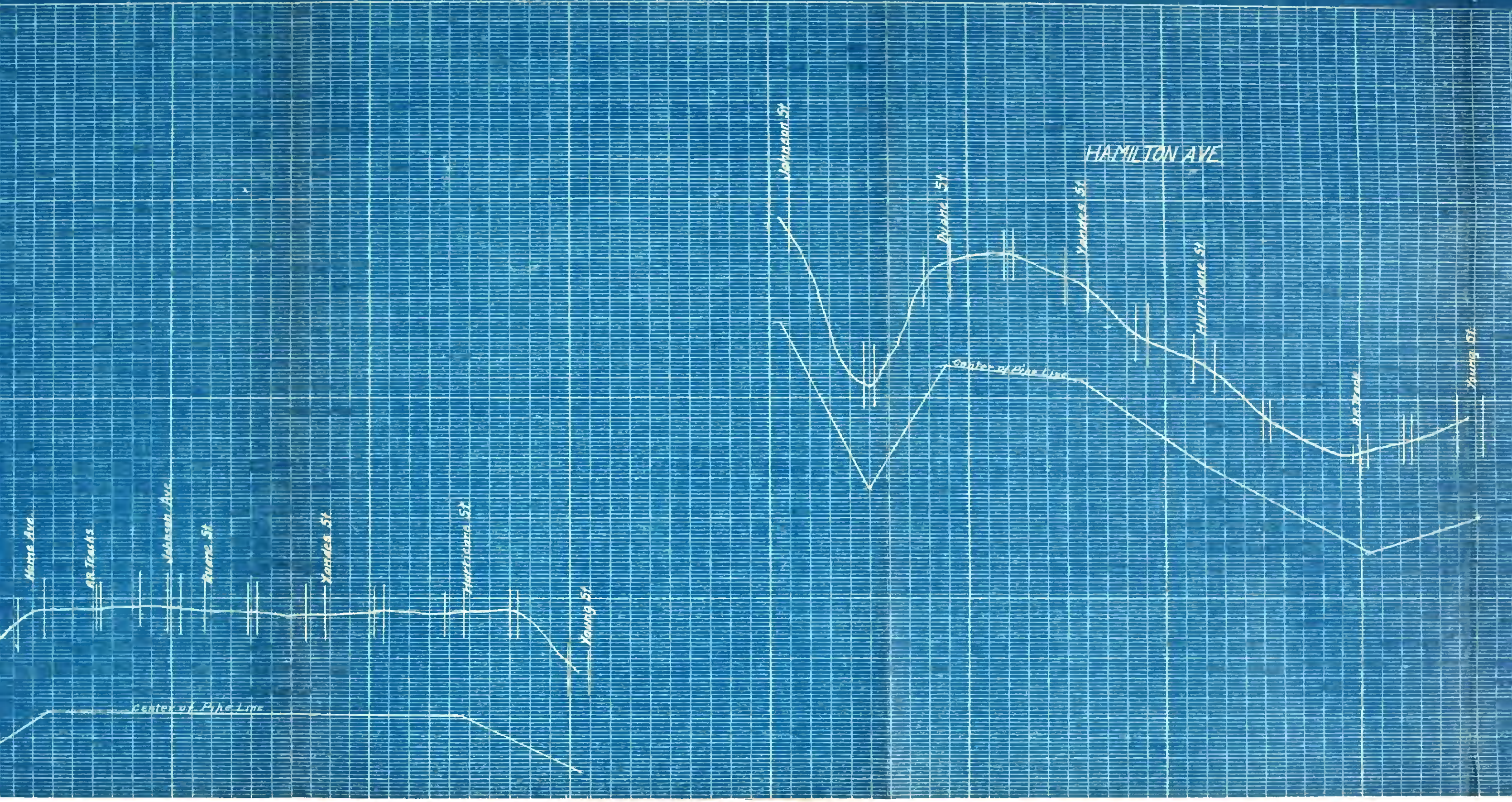

Morton St
Vaught St
Little St
MADISON ST
West St
Walnut St
Breckinridge St
RR Track
Creek
Jackson St
Main St
Water St
Center of Pipe Line


MADISON ST
West St
Walnut St
Breckenridge St
RR Track
Creek
Jackson St
Main St
Center of Pipe Line
Water St
Home Ave
RR Tracks
Yadkes St
Hurricane St

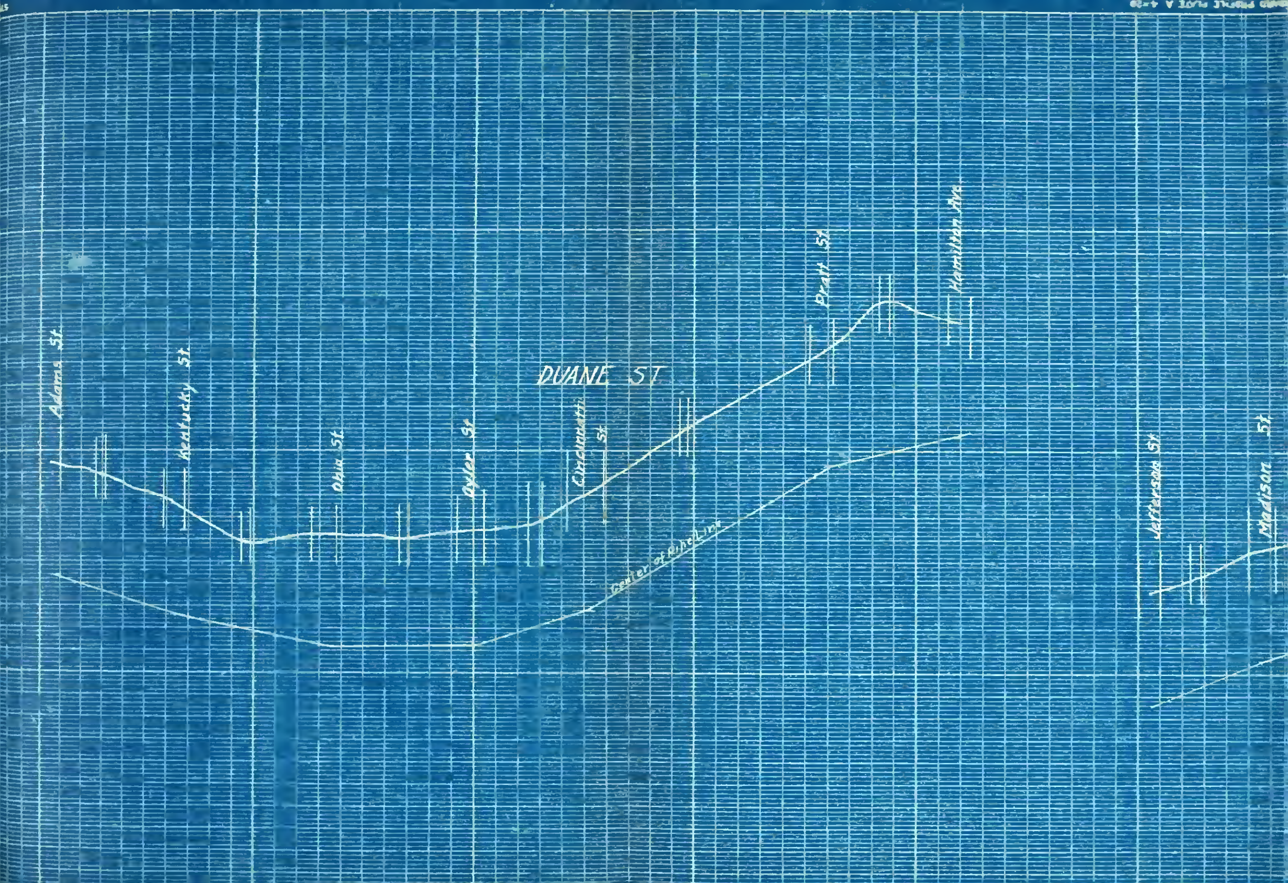

HAMILTON AVE
Duane St
Yandes St
Hurricane St
Center of Pipe Line



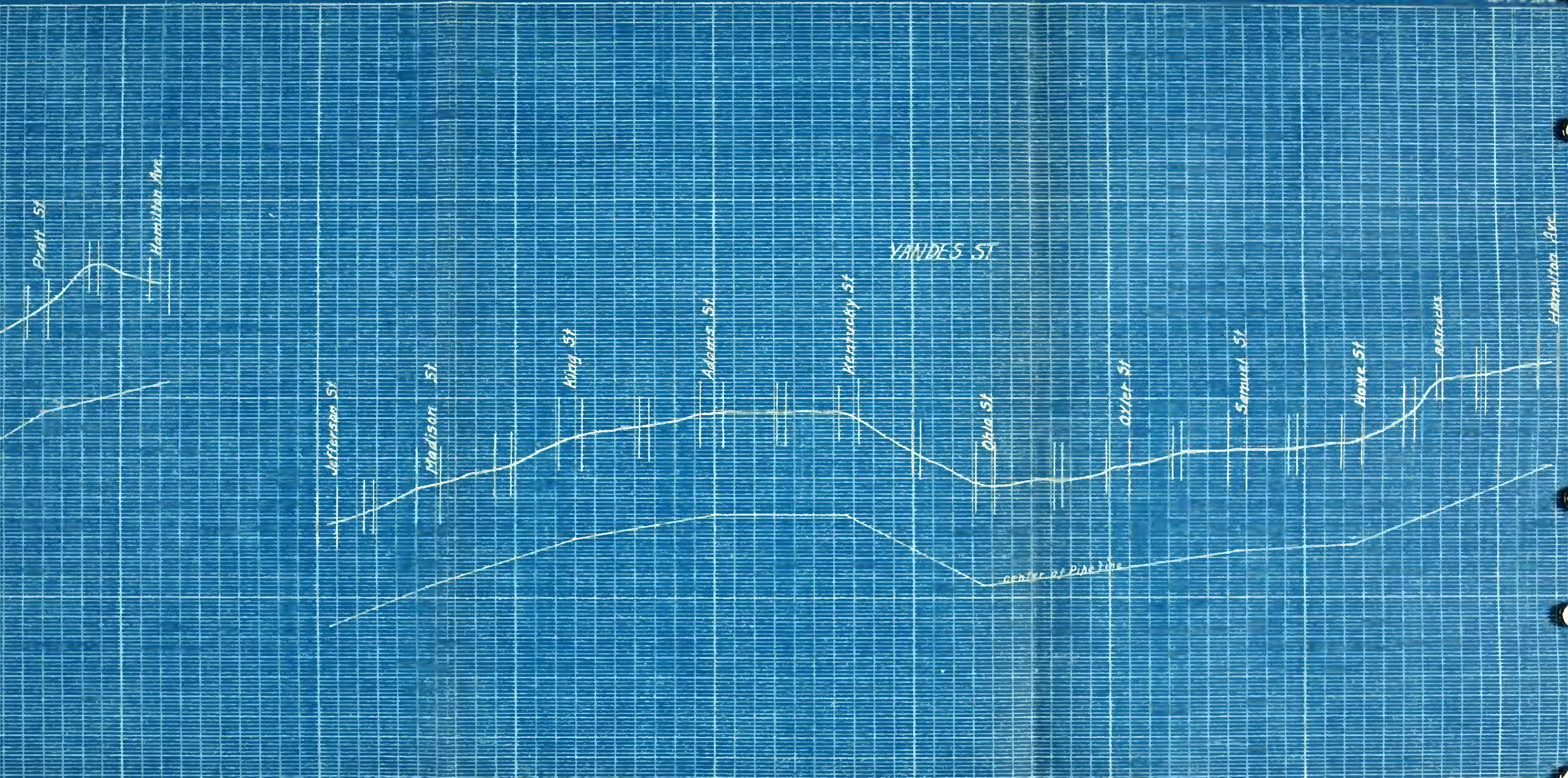
Marion St
Wright St
Miller St
West St
ADAMS ST.
Walnut St
Breckinridge St
Jackson St
RR Track
Main St
Water St
Rich St
RR Tracks



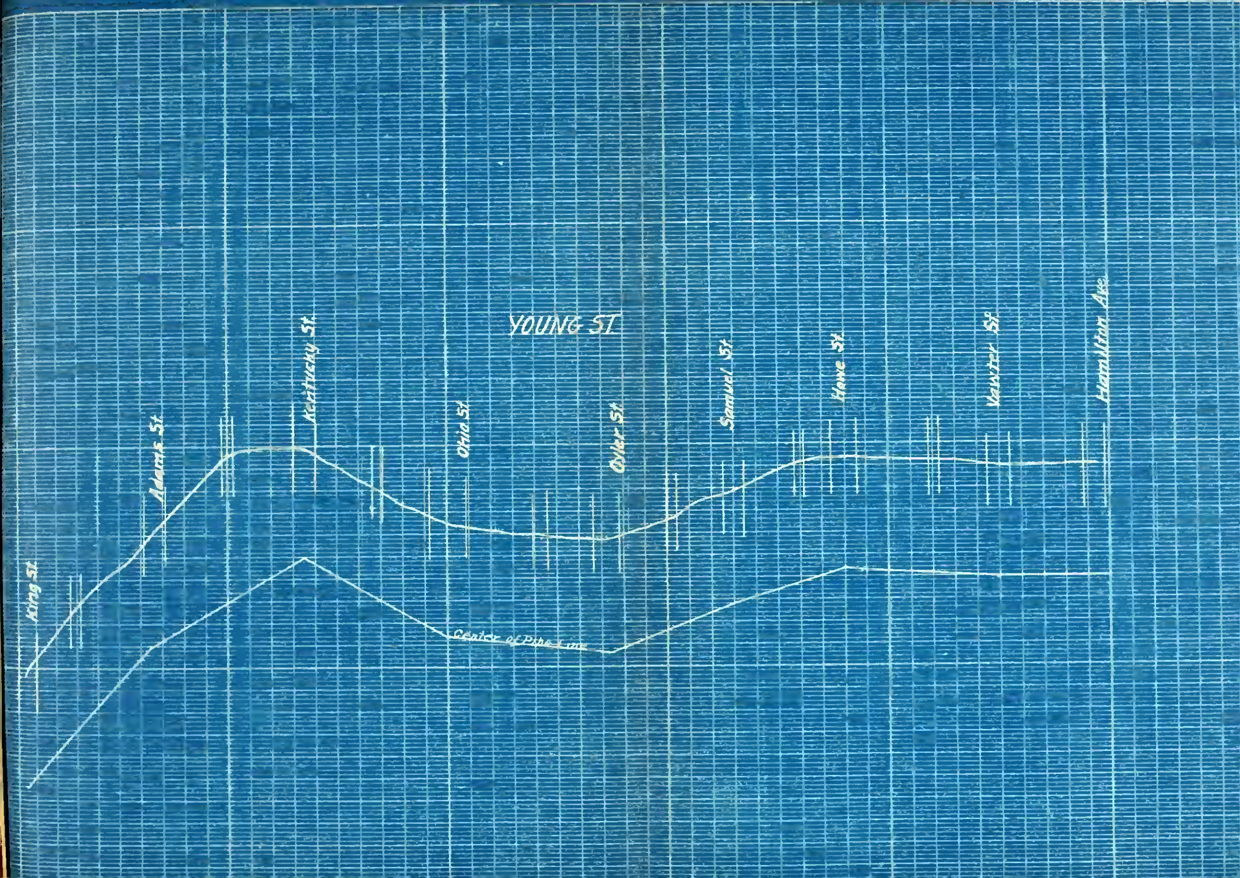
HAMILTON AVE.
Johnson St.
Duane St.
Yandes St.
Hurricane St.
RR Track
Young St.
Center of Pipe Line
Home Ave.
RR Tracks
Johnson Ave.
Duane St.
Yandes St.
Hurricane St.
Young St.
Center of Pipe Line



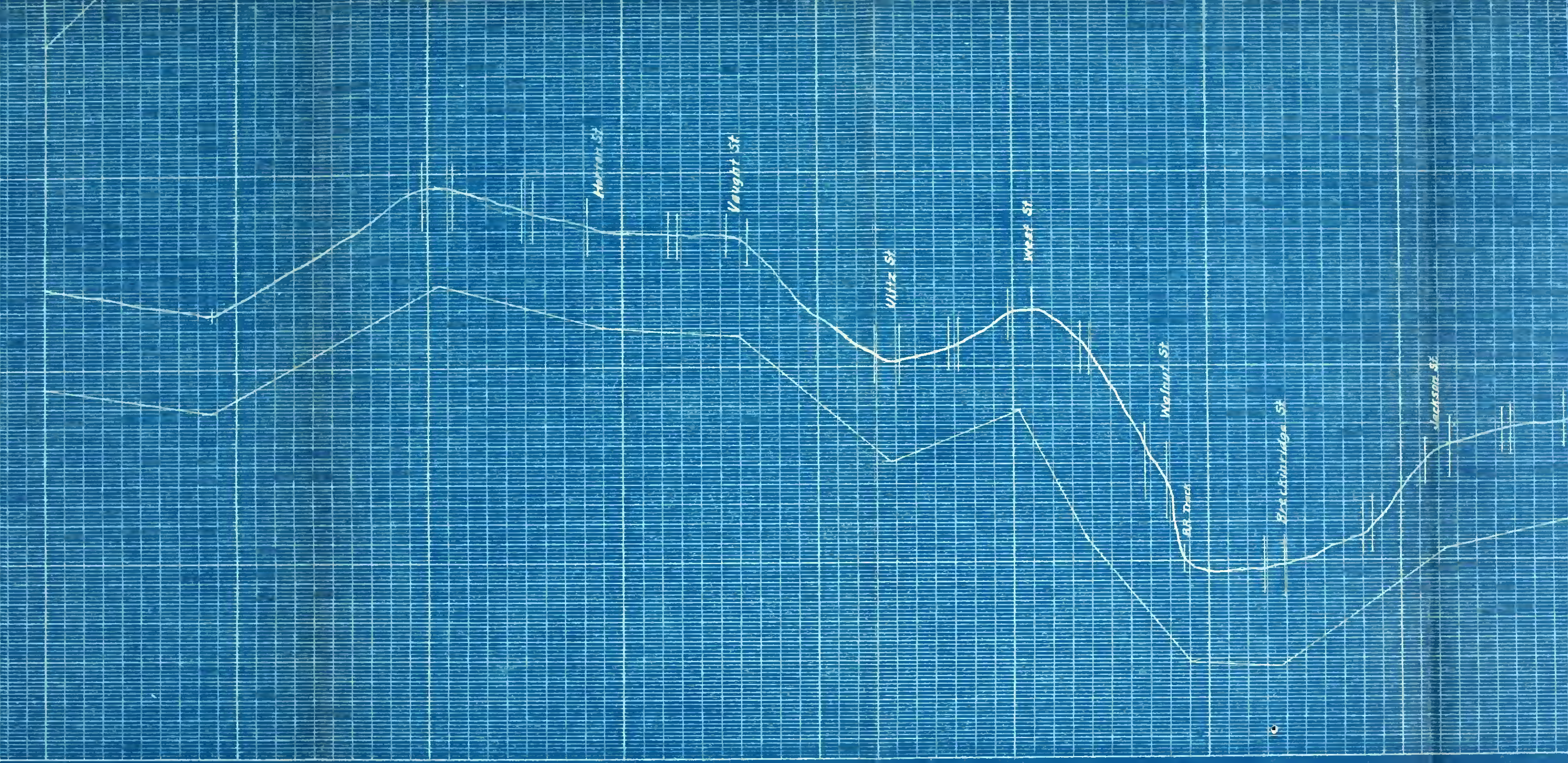
Adams St
Kentucky St
Ohio St
Cincinnati St
DUANE ST
Pratt St
Hamilton Ave
Center of Pipe Line
Jefferson St
Madison St

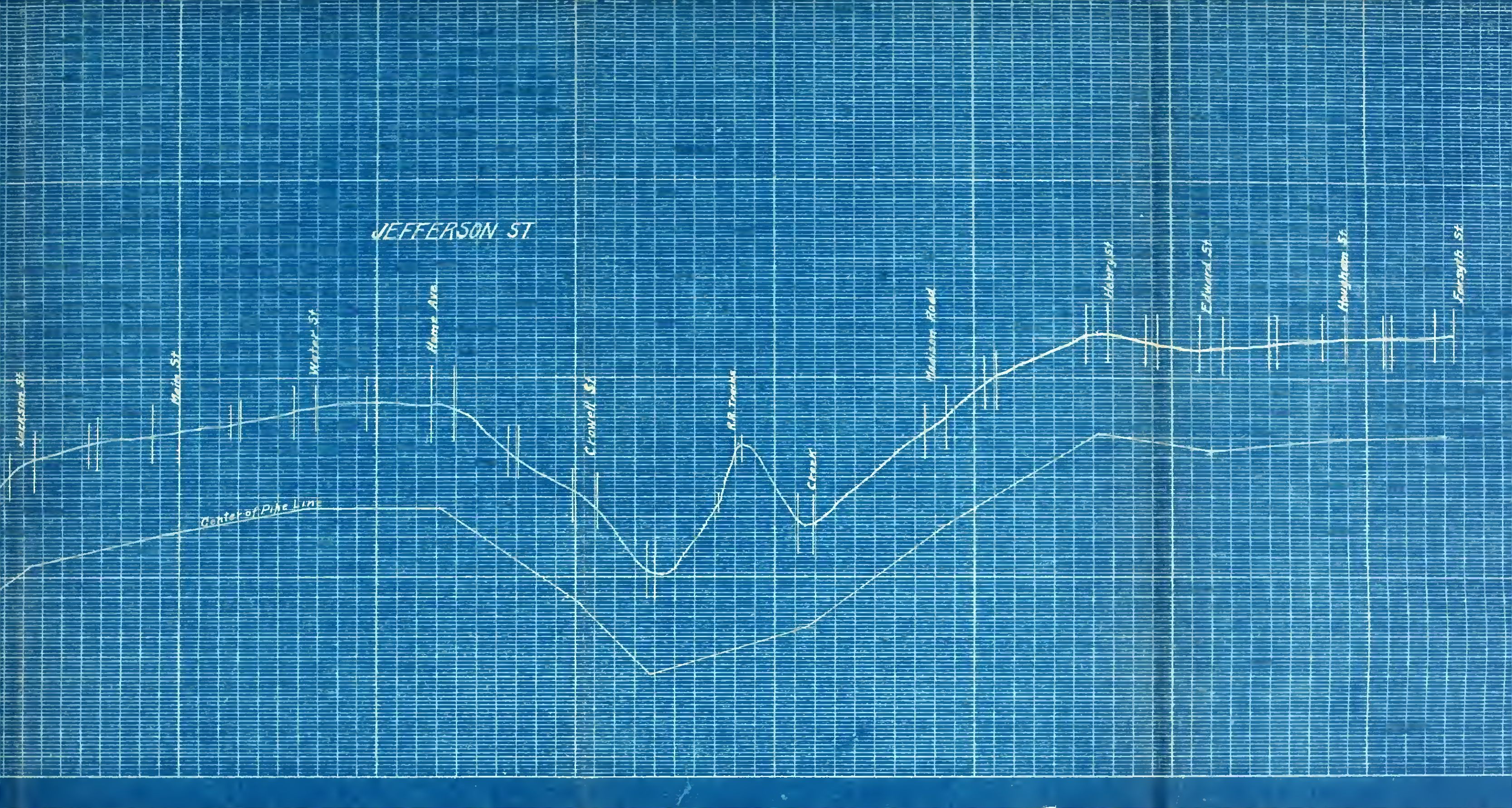


Pratt St
Hamilton Ave
YANDES ST
Jefferson St
Madison St
King St
Adams St
Kentucky St
Ohio St
Tyler St
Samuel St
Howe St
R.R. Tracks
Hamilton Ave
Center of Pipe Line

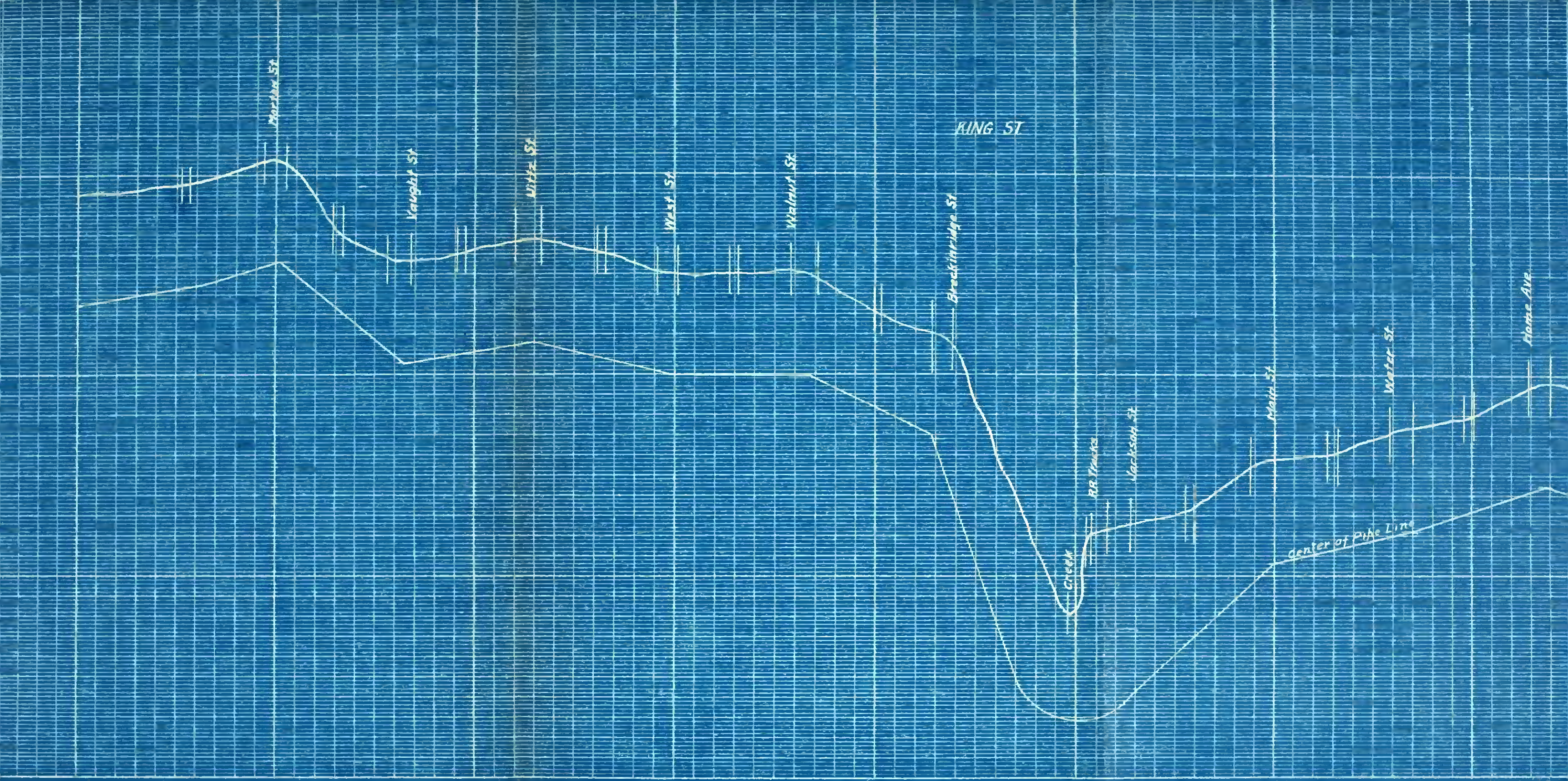


YOUNG ST.
King St
Adams St
Kentucky St
Ohio St
Oller St
Samuel St
Howe St
Hamilton Ave
Center of Pipe Line

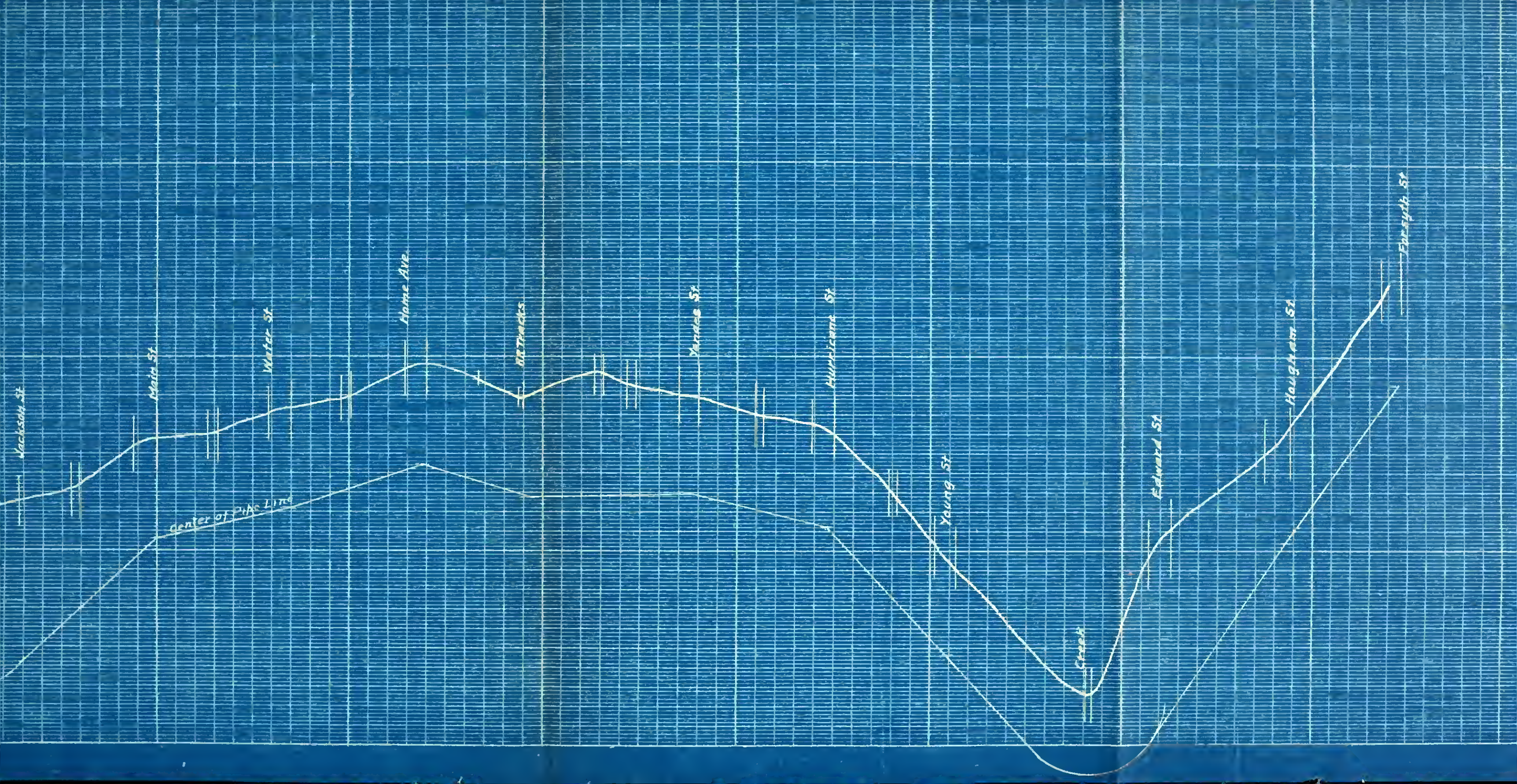

Vaught St
West St
Walnut St
R.R. Track
Breckinridge St
Jackson St


JEFFERSON ST.
Jackson St
Main St
Water St
Home Ave.
Crowell St
R.R. Tracks
Madison Road
Edward St
Hougham St
Forsyth St
Center of Pipe Line

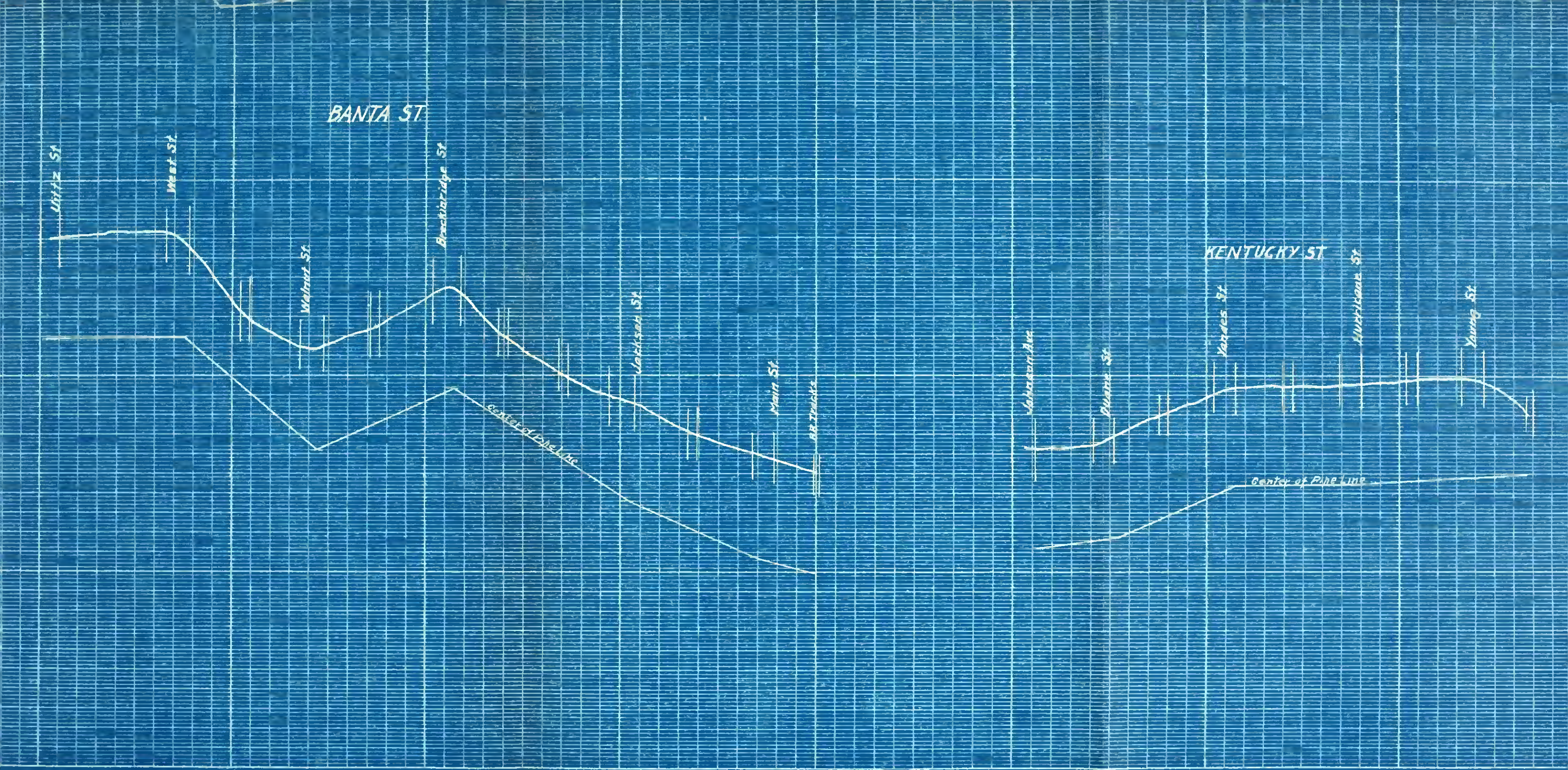

Crowell St.
R.R. Tracks



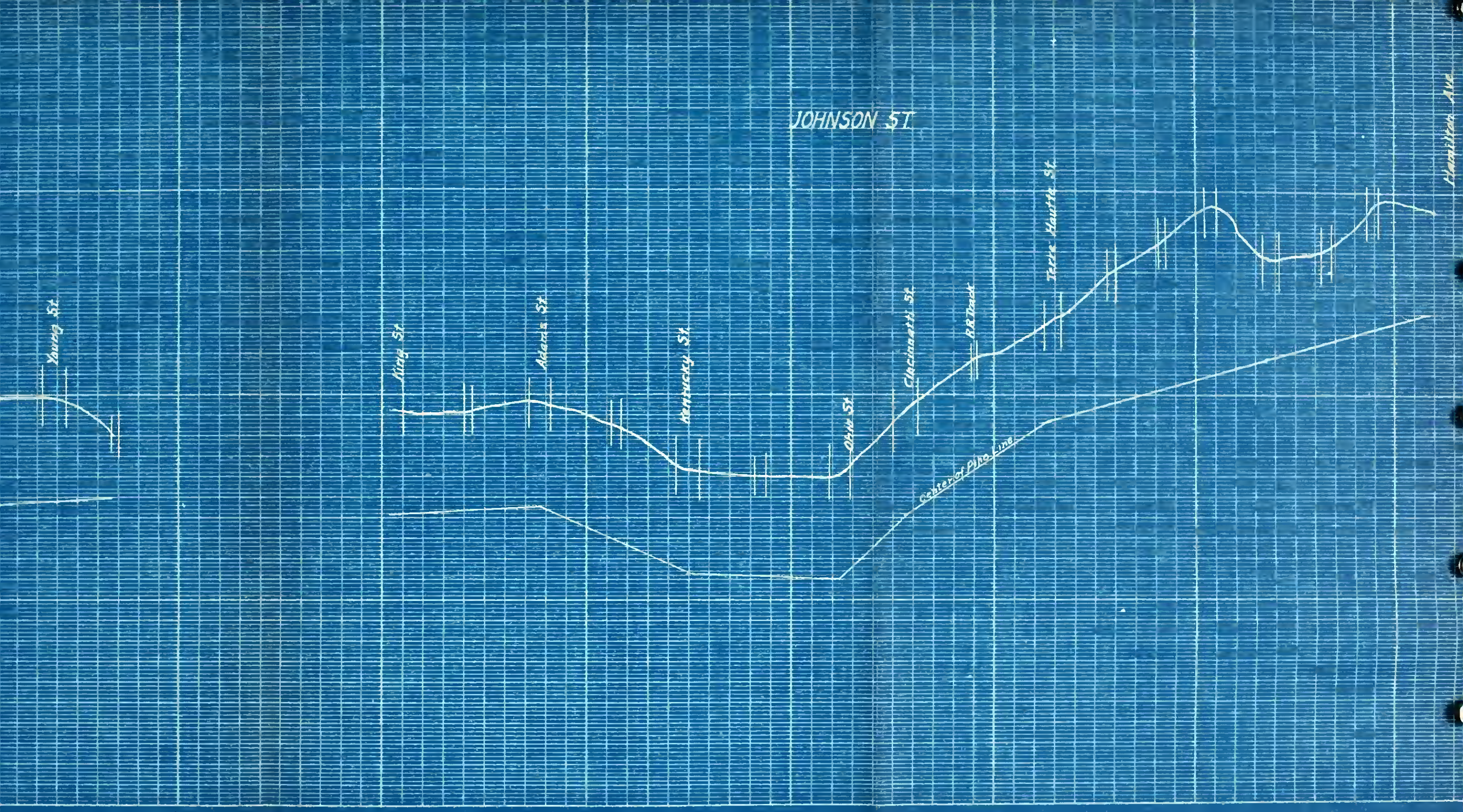
KING ST
Horton St
Vaught St
Uttz St
West St
Walnut St
Breckinridge St
Creek
RR Tracks
Jackson St
Main St
Water St
Home Ave
Center of Pipe Line

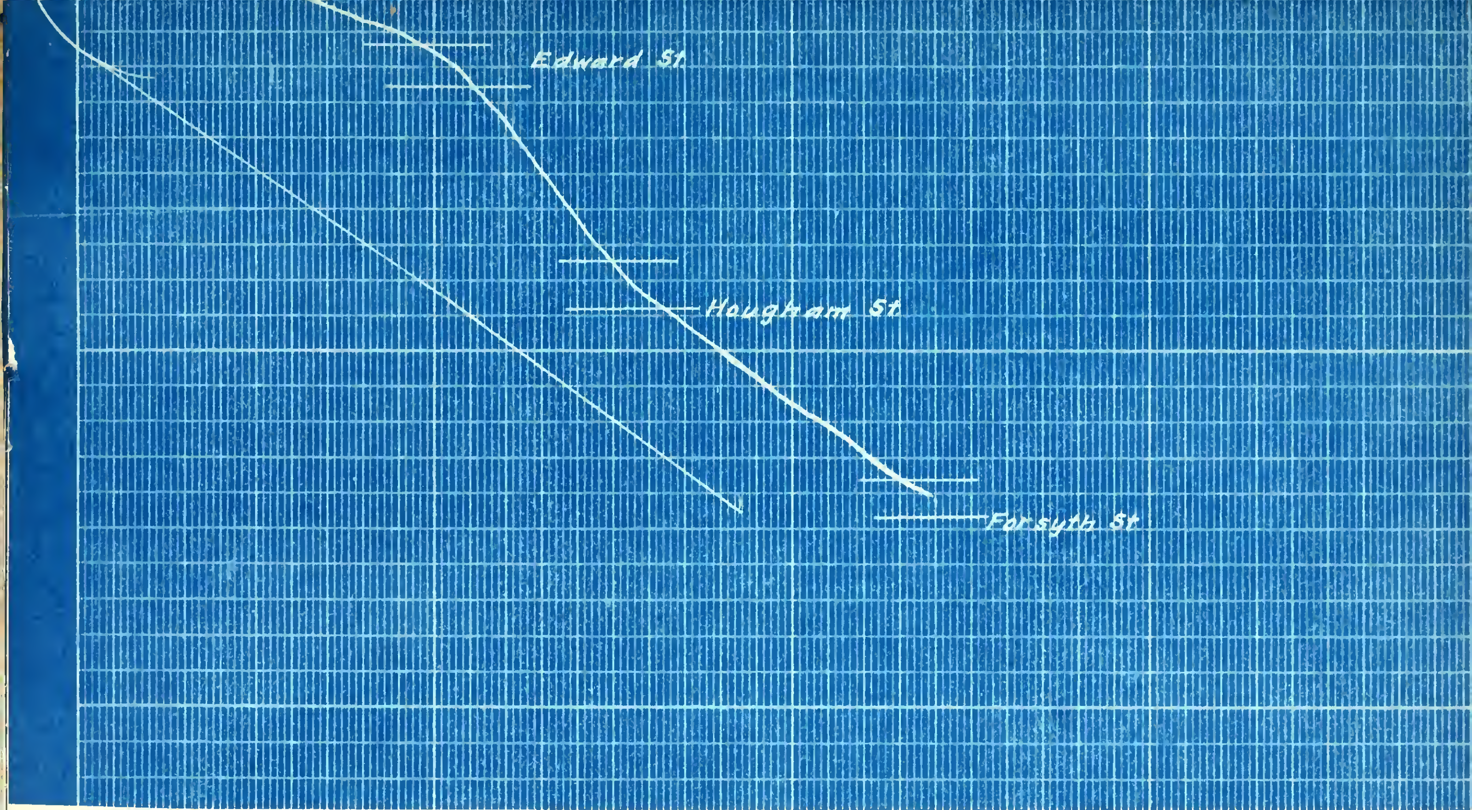


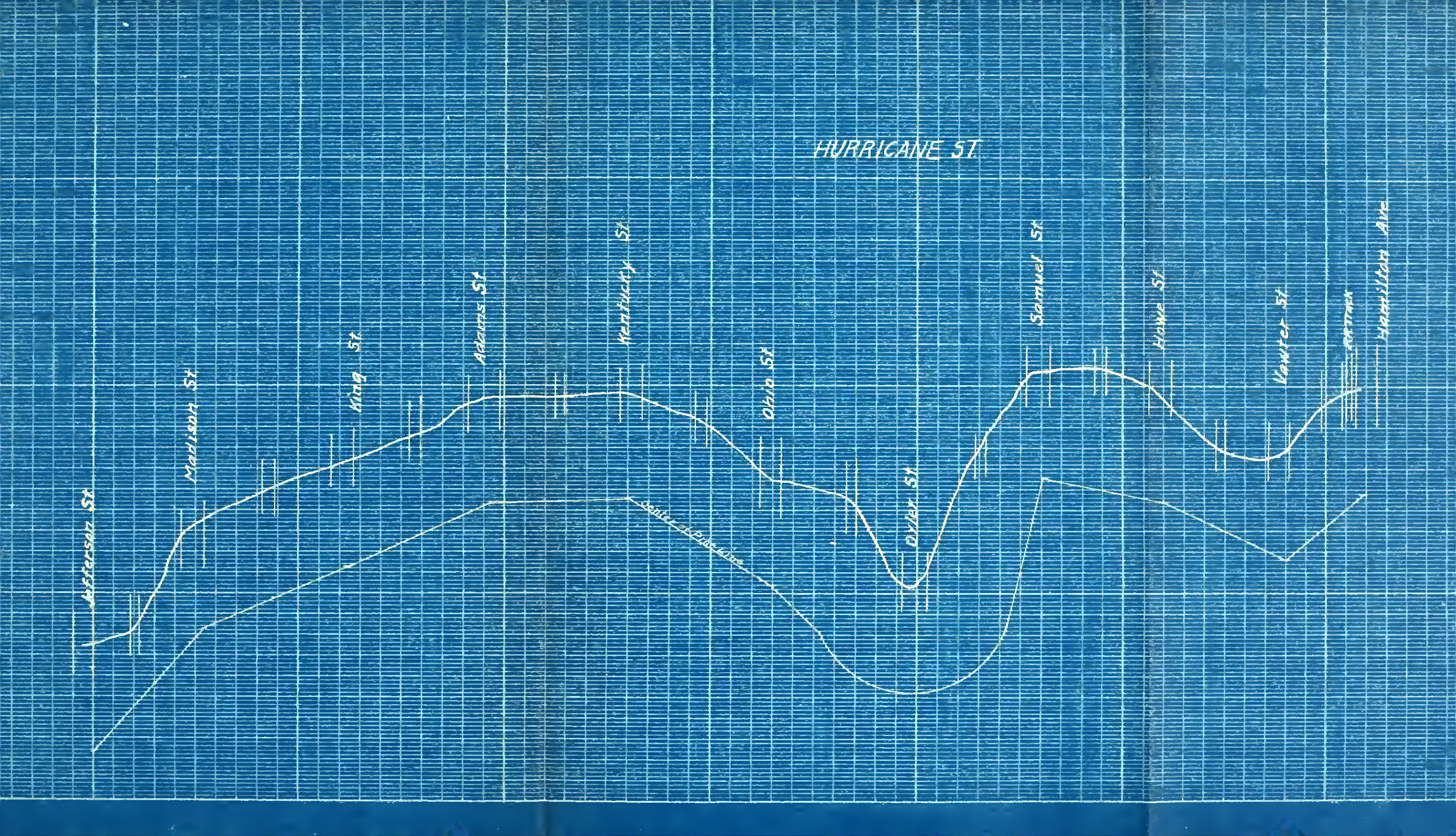
Jackson St
Main St
Water St
Home Ave
RR Tracks
Yandes St
Hurricane St
Young St
Creek
Edward St
Hougham St
Forsyth St
Center of Pipe Line



BANTA ST
Uhlitz St
West St
Walnut St
Breckinridge St
Jackson St
Main St
RR Tracks
Center of Pipe Line
KENTUCKY ST
Johnson Ave
Duane St
Yandes St
Hurricane St
Young St
Center of Pipe Line

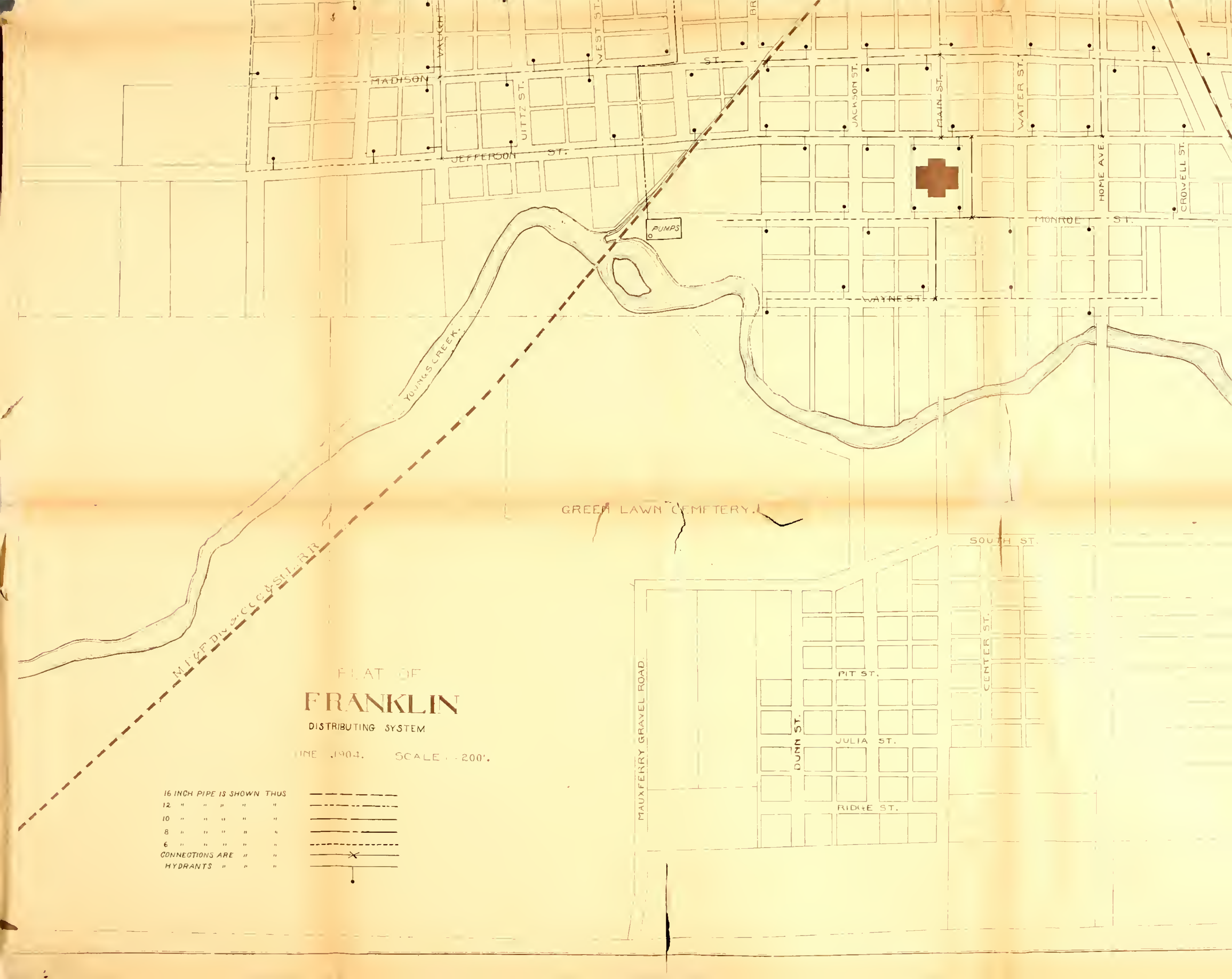

JOHNSON ST.
Young St.
King St.
Adams St.
Kentucky St.
Ohio St.
Cincinnati St.
R.R. Track
Terre Haute St.
Hamilton Ave.
Center of Pipe Line


Edward St
Hougham St
Forsyth St


HURRICANE ST
Jefferson St
Madison St
King St
Adams St
Kentucky St
Center of Pipe Line
Ohio St
Oliver St
Samuel St
Howe St
Vawter St
Hamilton Ave

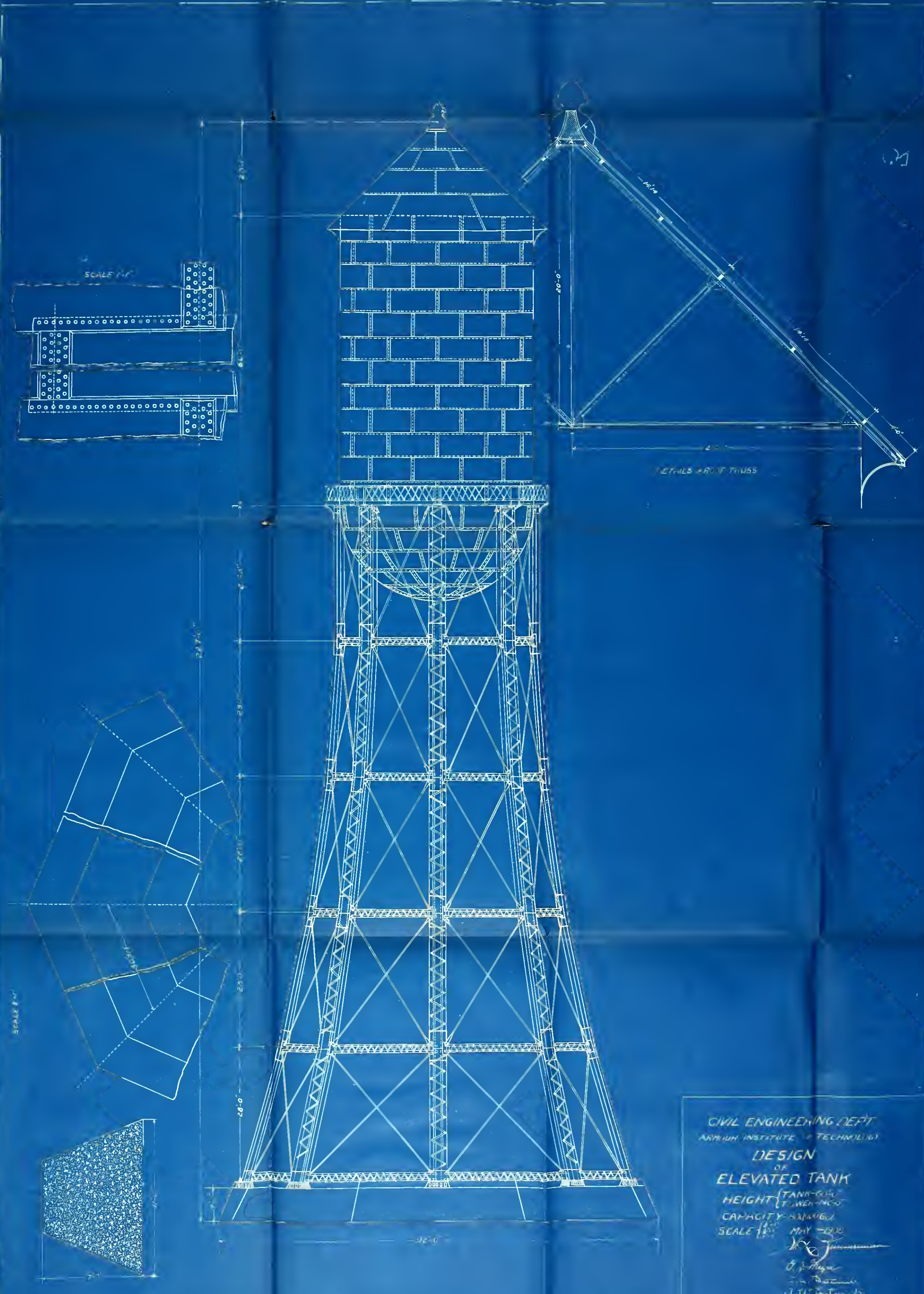

GREENWOOD TURNPIKE.
CENTRAL AVE.
HERRIOTT ST.
GRAHAM TURNPIKE.
P C C & St L R R
PRATT ST.
HOWE S
TERRE HAUTE ST.
SAMUEL S
CINCINNATI ST.
OYLER S
OHIO ST
YANDES ST.
KENTUCKY ST.
RICH ST.
DUANE ST.
MORTON ST.
WALNUT ST.
ADAMS ST.
BRECKINRIDGE ST.
KING ST.
VAUGHT ST.
WEST ST.
MADISON
ST.

GREENWOOD
TURNPIKE
P.C.C. & St.L.R.R.
GRAHAM TURNPIKE
HAMILTON AVE.
BENNETT ST.
VAWTER ST.
PRATT ST.
HOWE ST.
TERRE HAUTE ST.
JOHNSON AVE.
SAMUEL ST.
CINCINNATI ST.
OYLER ST.
OHIO ST.
YANDES ST.
HURRICANE ST.
YOUNG ST.
KENTUCKY ST.
DUANE ST.
RICH ST.
BARTA ST.
WALNUT ST.
ADAMS ST.
BRECKINRIDGE ST.
WEST ST.
TANK

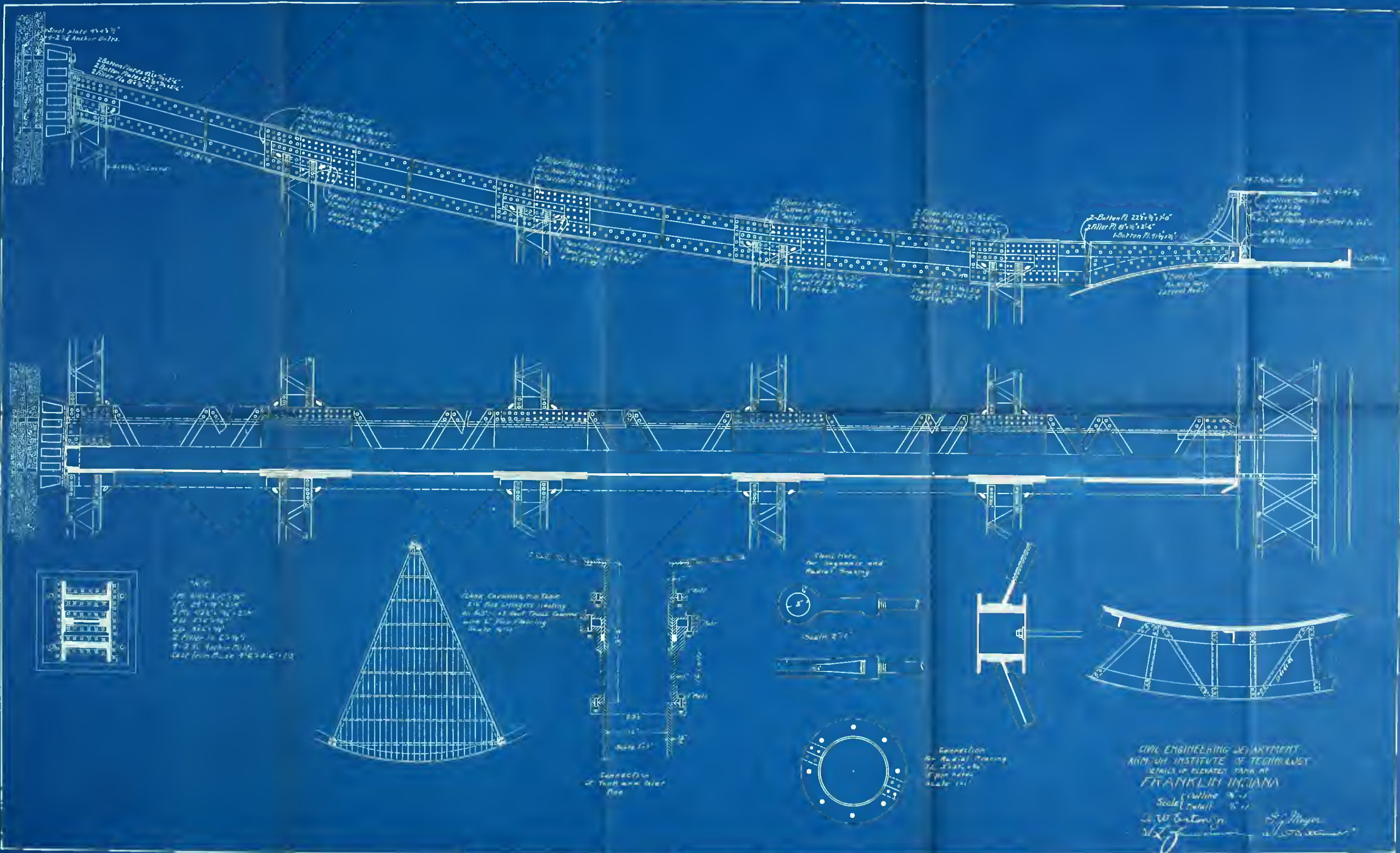


PLAT OF
FRANKLIN
DISTRIBUTING SYSTEM
1904.
SCALE
200'.
16 INCH PIPE IS SHOWN THUS
12 " " " " "
10 " " " " "
8 " " " " "
6 " " " " "
CONNECTIONS ARE " "
HYDRANTS " " "
MADISON
ST.
JEFFERSON
ST.
WEST ST.
JACKSON ST.
MAIN ST.
WATER ST.
HOME AVE.
CROWELL ST.
MONROE
ST.
WAYNE ST.
PUMPS
YOUNGS CREEK.
GREEN LAWN CEMETERY.
SOUTH ST.
CENTER ST.
PIT ST.
JULIA ST.
RIDGE ST.
DUNN ST.
MAUXFERRY GRAVEL ROAD.

ST.
JACKSON ST.
MAIN ST.
WATER ST.
HOME AVE.
CROWELL ST.
HENRY ST.
EDWARD ST.
HOUGHAM ST.
FORSYTH ST.
PUMPS
MONROE ST.
WAYNE ST.
DAME ST.
PARK ST.
CEMETERY.
SOUTH ST.
CENTER ST.
PIT ST.
DUNN ST.
JULIA ST.
RIDGE ST.
MADISON ROAD.


DETAILS OF ROOF TRUSS
20'-0"
20'-0"
28'-0"
92'-0"
CIVIL ENGINEERING DEPT
ARMOUR INSTITUTE OF TECHNOLOGY
DESIGN
OF
ELEVATED TANK
HEIGHT { TANK
TOWER
CAPACITY
SCALE
MAY

a. a. Dettmar.


CIVIL ENGINEERING DEPARTMENT
ARMOUR INSTITUTE OF TECHNOLOGY
DETAILS OF ELEVATED TANK AT
FRANKLIN INDIANA
Scale Outline
Detail